114th Congress, 1st Session – – – – – – – – – – – – – – House Document 114–65

COMPREHENSIVE EVERGLADES RESTORATION PLAN, CENTRAL EVERGLADES PLANNING PROJECT, INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT: FINAL JULY 2014, REVISED DECEMBER 2014

COMMUNICATION

FROM

THE ASSISTANT SECRETARY OF THE ARMY, CIVIL WORKS, THE DEPARTMENT OF DEFENSE

TRANSMITTING

THE FINAL COMPREHENSIVE EVERGLADES RESTORATION PLAN INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT, PURSUANT TO THE WATER RESOURCES DEVELOPMENT ACT OF 2000, SEC. 601

PART 3 OF 6



OCTOBER 6, 2015.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

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U.S. GOVERNMENT PUBLISHING OFFICE

97–170 WASHINGTON : 2015

AUTHENTICATED
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RESTORING THE HEART OF THE EVERGLADES

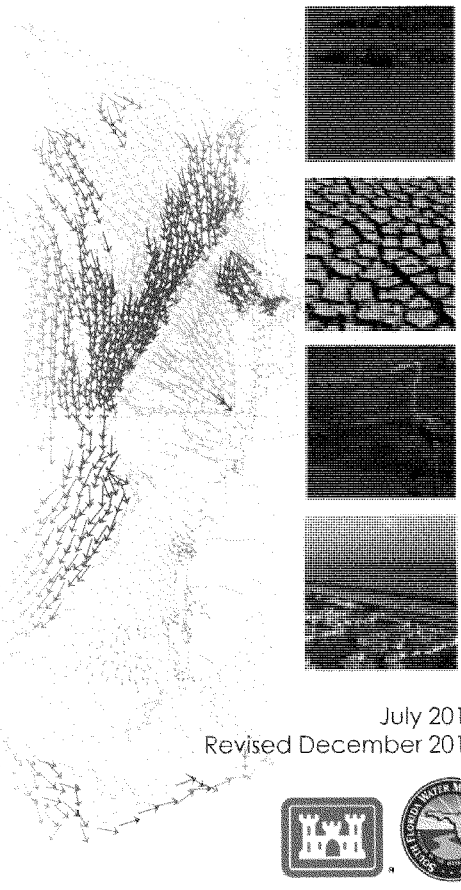
CENTRAL EVERGLADES PLANNING PROJECT



COMPREHENSIVE EVERGLADES RESTORATION PLAN

CENTRAL EVERGLADES PLANNING PROJECT

FINAL INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT



July 2014
Revised December 2014

Appendix A - Annex G Part 2

Cover insets (left to right):

Landscapes: Lake Okeechobee, Water Conservation Area 3, Everglades National Park, Florida Bay; **Map:** Depicts Average Annual Overland Flow across the period of record (1965-2005) for existing conditions, as modeled by the CEPP regional hydrologic model (the coloration of the arrows represents the relative volume of flow, while the direction of the arrows represents the movement of flow across the landscape); **Small Landscapes:** Ponding, soil oxidation (peat reduction), dry area of Everglades National Park, juxtaposition of urban development.

APPENDIX 5
LABORATORY TEST RESULTS
ROCK QUALITY TESTS

EAA Reservoir
Project 05 05 0013 016A
Work Order No: 4

Compressive Strength of Rock Cores

Core Identification	Core Depth (feet)	Compressive Strength (psi)
CB-0158	1.0-5.5	2600
CB-0159	4.75-9.75	1250
CB-0161	4.5-8.0	1430
CB-0163	5.5-10.5	4340
CB-0165	6.5-11.5	3690
CB-0167	6.5-11.5	1530
CB-0172	2.5-7.5	1570
CB-0173	5.0-5.5	1860
CB-0175	3.5-6.5	4620
CB-0176	1.0-5.0	2650
CB-0177	4.5-9.5	3090
CB-0178	9.5-12.0	433
CB-0179	0.4-3.5	1676
CB-0187	2.5-3	1105
CB-0187	25-30	2400
CB-0188	1.0-6.0	650
CB-0211	5.0-10.0	5200
CB-0212	10.0-15.0	2710
CB-0212	3.0-3.5	5920
CB-0184	4-9	1870

Notes:

1 Core compressive strength determined in general accordance with ASTM D2938

EAA Reservoir
Project 05 05 0013 016A
Work Order No: 6

Compressive Strength of Rock Cores

CP05 - EAAR5 - CB)

Core Identification	Core Depth (feet)	Compressive Strength (psi)
CB-0248 (K-0346)	5.0-10.0	5010
CB-0260 -0358	8.5-13.0	2500
CB-0268 -0365	6.5-11.5	1500
CB-0276 -0372	4.0-9.0	3570
CB-0276 -0372	10.0-14.0	1570
CB-0277 -0373	4.5-9.5	1000
CB-0277 -0373	9.5-14.5	4430
CB-0281 -0377	5.5-10.5	3880
CB-0281 -0377	10.5-15.5	2250
CB-0302 -0398	7.0-12.0	2100
CB-0302 -0398	12.0-17.0	1040

Notes:

1 Core compressive strength determined in general accordance with ASTM D2938

Nodarse & Associates, Inc.

Date: 10/18/2005
Project No: 05-05-0013-101 W.O.#5
Project Name: EAA Reservior
Requested by: Black & Veatch

2005 - 0262 - 0373

Sample No.	Length(inches)	Avg Diameter(inches)	Load (lbs)	Strenght(psi)	Comments
CB-0162 7-12 ft	-0262 4.83	2.48	47180	9768	
CB-0191 9.6-10.9ft	-0290 4.83	2.48	4220	874	
CB-0191 24-29ft	-0290 4	2.48	10700	2215	
CB-0194 41.5-45.5ft	-0293 83	2.49	5120	1053	
CB-0204 10-15ft	-0303 4.86	2.49	41020	8389	
CB-0205 9.5-14.5ft	-0304 4.86	2.49	15530	3195	
CB-0208 8.25-11.0ft	-0306 4.86	2.49	39270	8080	
CB-0216 26.1-27ft	-0314 4.86	2.46	14090	2979	
CB-0216 32.9-34.1ft	-0314 4.73	2.49	23890	4916	
CB-0220 19.9-25ft	-0318 4.89	2.49	4650	960	
CB-0220 25.0-30.0ft	-0319 4.86	2.49	15040	3095	
CB-0222 17.5-18.1ft	-0320 4.86	2.49	7200	1481	
CB-0231 2.0-7.0ft	-0329 4.52	2.47	8440	1867	
CB-0292 0-5.0ft	-0388 4.79	2.47	10150	2119	
CB-0296 0-5.0ft	-0392 4.83	2.48	8720	1805	

Nodarse & Associates, Inc.

Date: 10/4/2005

Project Name: EAA Reservoir A-1

Project No: 05-06-0013-101 WO#5

Tested by: Chris B

Depth See sample #

Checked by: Chris B

ASTM D 6473-99 Test Method

Specific Gravity & Absorption of Rock for Erosion Control

CPOS-CAR23-CB

Sample No.	Wt.in H2O (C) gr.	SSD Wt. (B) gr.	Oven Dry Wt. (A) gr.	Bulk Sp G.	Bulk (SSD) Sp. Gr	Apparent Sp. Gr	Absorption	Comments
	-0290							
CB-0101 24-29ft	320.1	544.1	516.8	2.31	2.43	2.63	5.26	
	-0293							
CB-0104 37.8-38.5ft	663.1	1157.8	1062	2.14	2.34	2.66	9.02	
	-0300							
CB-0201 10-10.7ft	968.1	1631.5	1555.2	2.31	2.42	2.61	7.96	
	-0303							
CB-0204 10-15ft	548.2	981.7	889.1	2.05	2.26	2.61	10.43	
	-0306							
CB-0208 8.25-11ft	815.2	1348.1	1310.8	2.47	2.53	2.64	2.69	
	-0315							
CB-0220 19.9-25ft	562.5	1023.5	889.2	1.93	2.22	2.72	15.1	
	-0315							
CB-0220 25-30.0ft	668.2	1142.6	1059.4	2.19	2.36	2.31	7.85	

Bulk spec. gravity =A/(B-C)

Bulk spec. gravity(SSD)=B/(B-C)

Apparent spec. gravity=A/(A-C)

Absorption = [(B-A)/A]X100%

EAA Reservoir
05 05 0013 106A
Work Order No: 4
Rock Core Specific Gravity and Absorption

CB05-ERRS-

Core Identification	Core Depth (feet)	Bulk Specific Gravity	Bulk (SSD) Specific Gravity	Apparent Specific Gravity	Absorption (%)
CB-0212	32.5-33.2	1.501	1.600	1.680	7.38
CB-0226	4.74-9.75	2.340	2.440	2.600	4.35
CB-0226	16.0-21.0	2.390	2.460	2.560	2.90
CB-0227	5.75-10.75	2.400	2.480	2.600	3.27
CB-0228	6.5-11.5	2.204	2.360	2.610	7.11
CB-0228	17.5-22.5	2.010	2.210	2.550	11.0
CB-0187	2.5-3.0	2.000	2.210	2.550	10.97
CB-0189	20.5-25.5	2.460	2.550	2.700	3.56
CB-0211	5.0-10.0	2.460	2.510	2.585	1.83
CB-0212	10.0-15.0	1.740	1.890	2.030	8.41
CB-0212	30.0-35.0	2.960	3.140	3.600	6.10
CB-0213	23.5-28.5	1.910	2.170	2.570	13.28
CB-0178	9.5-12.0	2.260	2.350	2.500	4.10
CB-0179	0.4-5.5	2.400	2.500	2.680	4.44
CB-0180	1.0-4.5	2.240	2.340	2.501	4.70
CB-0184	4.0-9.0	2.220	2.370	2.603	6.70
CB-0187	25.0-30.0	2.470	2.520	2.601	2.05
CB-0188	1.0-6.0	2.330	2.460	2.670	5.40
CB-0170	6.0-9.5	2.320	2.450	2.660	5.35
CB-0172	2.5-7.5	2.520	2.600	2.730	3.10
CB-0173	5.0-8.5	2.350	2.420	2.550	3.32
CB-0175	3.5-6.5	2.620	2.680	2.700	2.10
CB-0176	1.0-5.0	2.400	2.500	2.700	4.65
CB-0177	4.5-9.5	2.140	2.240	2.380	4.73
CB-0158	1.0-5.5	2.410	2.500	2.621	3.50
CB-0159	4.75-9.75	2.030	2.190	2.410	7.71
CB-0161	4.5-8.0	1.440	1.850	2.480	29.5

Notes:

1 Specific Gravity and Absorption determined in general accordance with ASTM D6473-99.

EAA Reservoir
05 05 0013 106A
Work Order No: 4
Rock Core Specific Gravity and Absorption

CPOS-ERRS-

Core Identification	Core Depth (feet)	Bulk Specific Gravity	Bulk (SSD) Specific Gravity	Apparent Specific Gravity	Absorption (%)
CB-0163	5.5-10.5	2.320	2.440	2.650	5.39
CB-0165	6.5-11.5	2.430	2.500	2.580	2.39
CB-0167	6.5-11.5	2.270	2.380	2.550	4.93
CB-0229	4.0-9.0	2.160	2.304	2.510	6.53
CB-0229	18.0-23.0	1.901	2.090	2.330	9.63
CB-0229	23.0-28.0	1.970	2.190	2.540	11.57
CB-0233	2.5-7.5	2.310	2.410	2.550	4.0

CB-0261
CB-0262
CB-0264
CB-0327
CB-0327
CB-0327
CB-0331

Notes:
2 Specific Gravity and Absorption determined in general accordance with ASTM D6473-99.

EAA Reservoir
05 05 0013 106A
Work Order No: 6
Rock Core Specific Gravity and Absorption

CP05- EARTS - CB

Core Identification	Core Depth (feet)	Bulk Specific Gravity	Bulk (SSD) Specific Gravity	Apparent Specific Gravity	Absorption (%)
CB-0248 -0346	5.0-10.0	2.42	2.49	2.60	2.90
CB-0260 -0358	2.0-7.0	2.40	2.50	2.50	1.51
CB-0260 -0358	8.5-13.0	2.17	2.30	2.50	6.10
CB-0268 0365	6.5-11.5	1.84	2.13	2.60	16.00
CB-0276 0372	4.0-9.0	2.17	2.34	2.60	7.87
CB-0276 0372	10.0-14.0	2.36	2.45	2.60	3.97
CB-0277 0373	4.5-9.5	2.23	2.37	2.60	6.20
CB-0277 0373	9.5-14.5	2.23	2.39	2.70	7.10
CB-0281 0377	5.5-10.5	2.19	2.33	2.60	6.78
CB-0281 0377	10.5-15.5	2.47	2.51	2.60	1.87
CB-0302 0398	7.0-12.0	2.04	2.20	2.40	7.90
CB-0302 0398	12.0-17.0	2.15	2.32	2.60	8.04

Notes: Specific Gravity and Absorption determined in general accordance with ASTM D6473-99.

Nodarse & Associates, Inc.

Date: 10/19/2005

Project Name: EAA Resivior A-1

Project No: 05-05-0013-101 WO#4

Tested by: Chris B

Depth See sample #

Checked by: Chris B

ASTM D 6473-99 Test Method

Specific Gravity & Absorption of Rock for Erosion Control

Sample No.	Wt Int'l20 (C) gr.	SSD Wt. (B) gr.	Oven Dry Wt. (A) gr.	Bulk Sp G.	Bulk (SSD) Sp. Gr	Apparent Sp. Gr	Absorption	Comments
Rip Rap sample 1	411.1	700.7	680.1	2.35	2.42	2.53	3.02	
Rip Rap sample 2	350.3	597.7	568.9	2.4	2.48	2.59	3.12	
Rip Rap sample 3	447.3	763.4	741.7	2.35	2.42	2.52	2.93	

Bulk spec. gravity =A/(B-C)

Bulk spec. gravity(SSD)=B/(B-C)

Apparent spec. gravity=A(A-C)

Absorption = [(B-A)/A]X100%

EAA Reservoir A-1
Laboratory Work Order No. 4, Rip Rap Samples
Los Angles Abrasion

Sample Number	1	2	3
Percent Wear	31.3	31.3	30.6
Grading	"A"	"A"	"A"

Note: Laboratory testing completed by Wingerter Laboratories Inc. of Miami Florida
Laboratory testing completed in accordance with ASTM C-131 & C-535.

EAA Reservoir A-1
Laboratory Work Order No. 4, Rip Rap Samples
Soundness of Rock

Sample Number	1	2	3
Percentage Loss	0%	0%	0%

Notes: Laboratory testing completed in general accordance with ASTM D5240.

APPENDIX 5
LABORATORY TEST RESULTS CARBONATE CONTENT

LABORATORY TEST RESULTS FOR
EAA RESERVOIR A-1
Nodarse & Associates, Inc. Project No. 05-05-0013

Boring Number	Sample Depth (ft)	Carbonate Content (%)
TC1-N-2	8.5	79.0
TC1-N-12	58.5	63.2
TC1-N-16	78.5	45.9
TC1-E-3	9.0	82.3
TC1-E-7	28.5	14.5
TC1-E-14	63.5	41.6
TC1-E-16	73.5	69.1
TC1-W-4	18.5	91.9
TC1-W-7	33.5	56.5
TC1-W-15	73.5	65.0
TC1-W-20	98.5	67.7
TC1-S-4	18.5	87.1
TC1-S-9	43.5	25.3
TC1-S-15	73.5	68.9
TC1-S-16	78.5	67.8
TC1-S-8	38.5	40.7

EAA Reservoir
05 05 0013 106A
Work Order No. 3
Carbonate Test Data

Boring Number	Depth (feet)	Carbonate Content (%)
CB 169 CB05-EAARS-CB-0260	5.5-8.5	76.6
CB 171 CB05-EAARS-CB-0268	7.0-10.0	81.6
CB 175 CB05-EAARS-CB-0271	13.5-15.0	81.8
CB 186 CB05-EAARS-CB-0281	33.5-35.0	34.7

227 TC-2 S 4
11.0'

Project Name: EAA
Project No:
Date: 2 24

NODARSE & ASSOCIATES, INC.

Carbonates

$C = \frac{(W-R)}{W} \times 100$ 89.5 %

Crucible Number:		T
Wt. Of Crucible:	B	72.7778
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	72.8828
Insoluble Residue: A-B = R	R	0.1050

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

App A Annex G-1 FZR Geological Investigations North of Redline

TC-2 W-8
33.5'

Project Name: EAA
Project No:
Date: 7-21

NODARSE & ASSOCIATES, INC.

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

23.3 %

Crucible Number:		105
Wt. Of Crucible:	B	76.4745
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	77.2415
Insoluble Residue: *A-B = R*	R	0.7670

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

App A Annex G-1

305

TC-2W 5
11.0'

Geological Investigations North of Redline

Project Name: ERA
Project No:
Date: 2 21

GODARSE & ASSOCIATES, INC.

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

78.6 %

Crucible Number:		500
Wt. Of Crucible:	B	70.8534
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	71.0673
Insoluble Residue: *A-B = R*	R	0.2139

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

App A Annex G-1

234

TC-26-5
18.5

Geological Investigations North of Redline

Project Name: EAA
Project No:
Date: 2 21

NODARSE & ASSOCIATES, INC.

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

80.6 %

Crucible Number:		C
Wt. Of Crucible:	B	75.5465
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	75.7410
Insoluble Residue: *A-B = R*	R	0.1945

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

234 TC-2 E S 18.5'

Project Name: EAA
Project No:
Date: 2 21



Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

80.6 %

Crucible Number:		C
Wt. of Crucible:	B	75.5465
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	75.7410
Insoluble Residue: $A-B=R$	R	0.1945

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

227 TC-2 S 4
11.0'

Project Name: EAA
Project No:
Date: 2 24

NODARSE & ASSOCIATES, INC.

Carbonates

$C = \frac{(W-R)}{W} \times 100$ 89.5 %

Crucible Number:		T
Wt. Of Crucible:	B	72.7778
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	72.8828
Insoluble Residue: *A-B = R*	R	0.1050

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

FtR

TC-2 W 8

33.5'

Project Name: EAA
Project No:
Date: 2-21

NODARSE & ASSOCIATES, INC.

Carbonates

$C = \frac{(W-R)}{W} \times 100$ 23.3 %

Crucible Number:		105
Wt. Of Crucible:	B	76.4745
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	77.2415
Insoluble Residue: *A-B = R*	R	0.7670

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

305 TC-2W 3
11.0'

NODARSE & Associates, Inc.

Project Name: EAA
Project No:
Date: 2 21

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

78.6 %

Crucible Number:		500
Wt. Of Crucible:	B	70.8534
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	71.0673
Insoluble Residue: *A-B = R*	R	0.2139

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

EAA Reservoir
05 05 0013 106A
Work Order No: 5
Carbonate Test Data

CP05 – EAA2S – VB

Boring Number	Depth (feet)	Carbonate Content (%)
CB-0174	100-105	71.7
CB-0174	110-115	75.5
CB-0174	115-120	75.9
CB-0174	125-130	77.7
CB-0174	140-145	53.0
CB-0174	150-155	68.3
CB-0174	160-165	67.2
CB-0174	165-170	41.2
CB-0174	180-185	37.9
CB-0174	185-190	53.6
CB-0174	195-200	36.6
CB-0174	200-205	23.9
CB-0174	205-210	30.5

Notes:

1 Carbonate content determined in general accordance with FDOT Standard.

EAA Reservoir
05 05 0013 106A
Work Order No. 6
Carbonate Test Data

0005 - ETTARS-VB -

Boring Number	Depth (feet)	Carbonate Content (%)
CB 164	55060	61.8
CB 164	70-75	72.3
CB 164	130-135	32.8
CB 164	180-185	54.8
CB 182	70-75	78.8
CB 182	90-95	72.1
CB 182	140-145	55.4
CB 182	175-180	48.2
CB 205	60-65	77.1
CB 205	75-80	72.0
CB 205	140-145	58.2
CB 205	160-165	61.6

281

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

102

BA-01
5.5-7.0'

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

87.4%

Crucible Number:		202
Wt. Of Crucible:	B	18.3244
Mass of Sample:	W	1.6001
Crucible + Insoluble Residue After Burn:	A	18.4508
Insoluble Residue: *A-B = R*	R	0.1264

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

BA-01
28.5-30.0'

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

29.1 %

Crucible Number:		C
Wt. Of Crucible:	B	75.5444
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	76.2531
Insoluble Residue: A-B = R	R	0.7087

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

App A Annex G-1 302 Geological Investigations North of Redline

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

BA-01
43.5-45.0'

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

10.9 %

Crucible Number:		203
Wt. Of Crucible:	B	17.2999
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	18.1907
Insoluble Residue: A-B = R	R	0.8908

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

216

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

BA-03
2.5 - 10.0'

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

82.6 %

Crucible Number:		105
Wt. Of Crucible:	B	25.8748
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	26.0486
Insoluble Residue: *A-B = R*	R	0.1738

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

200

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

BA-03
29-30.5'

Carbonates

$C = \frac{(W-R)}{W} \times 100$ 40.5 %

Crucible Number:		100
Wt. Of Crucible:	B	26.1823
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	26.7771
Insoluble Residue: *A-B = R*	R	0.5948

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

263

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

BA-03
43.5' - 45.0'

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

37.3%

Crucible Number:		105
Wt. Of Crucible:	B	25.8741
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	26.5013
Insoluble Residue: $A-B=R$	R	0.6272

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

253

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

101

BA-04, 6.2,

Carbonates

$C = \frac{(W-R)}{W} \times 100$ 87.7%

Crucible Number:		203
Wt. Of Crucible:	B	17.2991
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	17.4220
Insoluble Residue: *A-B = R*	R	0.1229

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

800

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

BA-64
18.5'

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

82.7 %

Crucible Number:		B
Wt. Of Crucible:	B	76.4770
Mass of Sample:	W	1.0001
Crucible + Insoluble Residue After Burn:	A	76.6500
Insoluble Residue: $A-B = R$	R	0.1730

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

 207

Project Name: EAA
Project No:
Date:

GDARSE & ASSOCIATES, INC.

BA-04 33.5'
Carbonates

$C = \frac{(W-R)}{W} \times 100$ 31.4%

Crucible Number:		101
Wt. Of Crucible:	B	25.2995
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	25.9857
Insoluble Residue: *A-B = R*	R	0.6862

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

222

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

B4-05
28.5'

Carbonates

$C = \frac{(W-R)}{W} \times 100$ 36.8 %

Crucible Number:		100
Wt. Of Crucible:	B	26.1721
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	26.8037
Insoluble Residue: *A-B = R*	R	0.6316

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

246

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

BA-05
8.6'

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

86.2 %

Crucible Number:		101
Wt. Of Crucible:	B	25.3000
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	25.4385
Insoluble Residue: *A-B = R*	R	0.1383

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

231

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

BA-05
38.5'

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

31.4 %

Crucible Number:		11
Wt. Of Crucible:	B	29.4254
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	30.1114
Insoluble Residue: *A-B = R*	R	0.6860

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

App A Annex G-1 TT-6 Geological Investigations North of Redline

Project Name: EAA
Project No:
Date:

BA-06
6.0-7.5'

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

84.7 %

Crucible Number:		100
Wt. Of Crucible:	B	26.1653
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	26.3184
Insoluble Residue: *A-B = R*	R	0.1531

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

Project Name: EAA
Project No:
Date:

BA-06
28.5-30.0'

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

27.6 %

Crucible Number:		C
Wt. Of Crucible:	B	75.5440
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	76.2680
Insoluble Residue: *A-B = R*	R	0.7240

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

BA-06
48.5-50.0'

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

34.6 %

Crucible Number:		102
Wt. Of Crucible:	B	25.6848
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	26.3388
Insoluble Residue: *A-B = R*	R	0.6540

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

BA-07
6.0 - 7.5'

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

83.0 %

Crucible Number:		204
Wt. Of Crucible:	B	17.8940
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	18.0643
Insoluble Residue: *A-B = R*	R	0.1703

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%



Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

B4.07
18.5-20.0'

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

84.8 %

Crucible Number:		202
Wt. Of Crucible:	B	18.3399
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	18.4918
Insoluble Residue: *A-B = R*	R	0.1519

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

BA-07
38.5-40.0'

Carbonates

$C = \frac{(W-R)}{W} \times 100$ 28.5 %

Crucible Number:		102
Wt. Of Crucible:	B	25.6892
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	26.4045
Insoluble Residue: *A-B = R*	R	0.7153

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

BA-08
8.5-10.0'

Carbonates

$C = \frac{(W-R)}{W} \times 100$ 85.9 %

Crucible Number:		105
Wt. Of Crucible:	B	25.8640
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	26.0054
Insoluble Residue: $A-B = R$	R	0.1414

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

252

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

BA-08
15.5 - 15.0'

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

83.7 %

Crucible Number:		11
Wt. Of Crucible:	B	29.4172
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	29.5807
Insoluble Residue: *A-B = R*	R	0.1635

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

225

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

BA-08
38.5-40.0

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

32.0 %

Crucible Number:		101
Wt. Of Crucible:	B	25.2934
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	25.9733
Insoluble Residue: *A-B = R*	R	0.3201

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

BA-09
23.5-25.0' 105

Carbonates

$$C = \frac{(W-R)}{W} \times 100$$

78.5 %

Crucible Number:		204
Wt. of Crucible:	B	17.9686
Mass of Sample:	W	1.0001
Crucible + Insoluble Residue After Burn:	A	18.0836
Insoluble Residue: *A-B = R*	R	0.2150

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

255

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

BA09
38.5-40.0'

Carbonates

$C = \frac{(W-R)}{W} \times 100$ 25.3 %

Crucible Number:		T
Wt. Of Crucible:	B	1.0001
Mass of Sample:	W	72.7716
Crucible + Insoluble Residue After Burn:	A	73.5187
Insoluble Residue: *A-B = R*	R	0.7471

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

SECA

Project Name: EAA
Project No:
Date:

NODARSE & ASSOCIATES, INC.

BA-10
13.5-15.0'

Carbonates

$C = \frac{(W-R)}{W} \times 100$ 83.5 %

Crucible Number:		A
Wt. Of Crucible:	B	75.0438
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	75.2091
Insoluble Residue: *A-B = R*	R	0.1653

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

241

Project Name: EAA
Project No:
Date:

BODARSE & ASSOCIATES, INC.

BA-10
33.5-35.0'

Carbonates

$C = \frac{(W-R)}{W} \times 100$

26.7 %

Crucible Number:		102
Wt. Of Crucible:	B	25.6924
Mass of Sample:	W	1.0000
Crucible + Insoluble Residue After Burn:	A	26.4250
Insoluble Residue: *A-B = R*	R	0.7326

C = % of Carbonates of Calcium and Magnesium
W = Mass Of Sample
R = Insoluble Residue

Carbonate Range:

90% and up ± 0.4%
50% and up ± 0.9%

APPENDIX 5
LABORATORY TEST RESULTS
OTHER TESTS

TRIAXIAL TEST RESULTS

Note: Material for triaxial tests on remolded samples was obtained from soil used in Test Cell construction.

EAA Reservoir
05 05 0013 106A
Work Order No: 5
Corrosion Test Data

CP05 - EAARS - VB - 1

Boring Number	Depth (feet)	Electrical Resisitivity (0hm-cm)	pH	Chlorides (ppm)	Sulfates (ppm)
-0283 CB-0174	5-10	8.2 x 1k	8.5	60	25
-0283 CB-0174	115-120	3.0 x 1k	8.3	60	Less than 5

Notes:

1 Corrosion Series determined in general accordance with FDOT Standards.

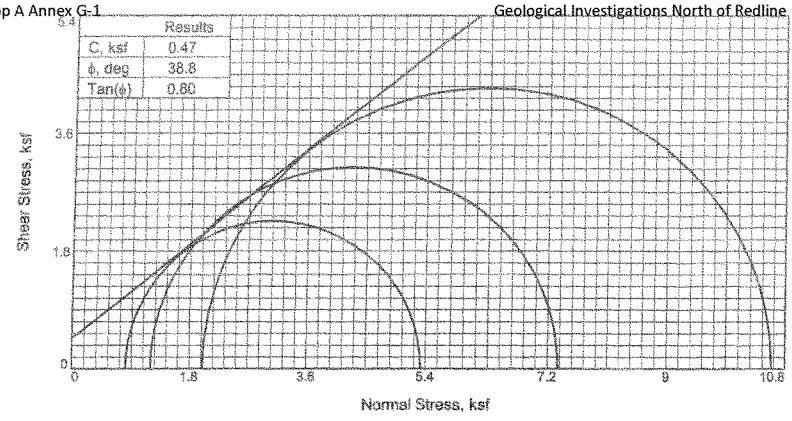
EAA Reservoir
05 05 0013 106A
Work Order No: 6
Corrosion Test Data

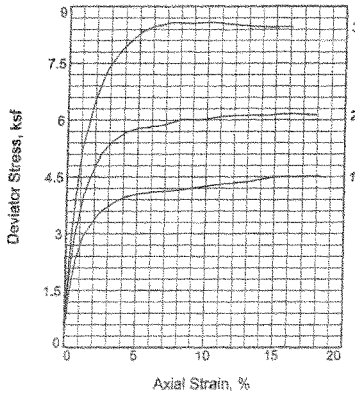
Boring Number	Depth (feet)	Electrical Resisitivity (0hm-cm)	pH	Chlorides (ppm)	Sulfates (ppm)
CB-0164	5-10	6.1 x 1k	8.9	90	60

1cp05 - EAA2S - CB - 0361

Notes:

1 Corrosion Series determined in general accordance with FDOT Standards.





Sample No.		1	2	3
Initial	Water Content,	15.9	16.2	15.8
	Dry Density, pcf	104.4	107.4	107.3
	Saturation,	67.4	74.0	71.9
	Void Ratio	0.6508	0.6047	0.6066
	Diameter, in.	2.84	2.84	2.84
	Height, in.	6.05	6.15	6.83
At Test	Water Content,	22.8	21.7	21.9
	Dry Density, pcf	105.8	107.8	107.5
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.6304	0.6000	0.6044
	Diameter, in.	2.83	2.84	2.84
	Height, in.	6.02	6.14	6.83
Strain rate, in./min.		0.05	0.05	0.05
Back Pressure, ksf		0.0	0.0	0.0
Cell Pressure, ksf		0.8	1.2	2.0
Fail. Stress, ksf		4.5	6.2	8.6
Ult. Stress, ksf				
σ_1 Failure, ksf		5.3	7.4	10.6
σ_3 Failure, ksf		0.8	1.2	2.0

Type of Test: Unconsolidated Undrained
Sample Type: remold
Description: Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments

Specific Gravity= 2.762
Remarks: sample moist cured 14 days

Reviewed By _____

Client: Nodarse and Associates

Project: Material Testing-Nodarse

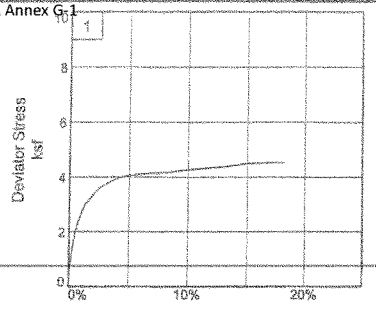
Sample Number: UU-95% 14 day cured

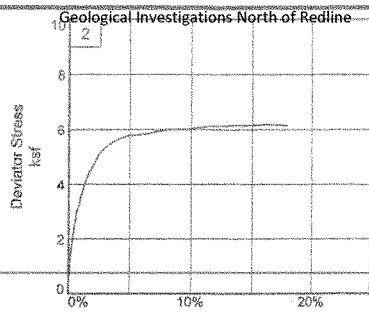
Proj. No.: 6738-05-4573 **Date:** 6-28-05

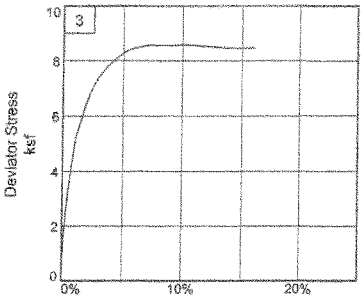
TRIAXIAL SHEAR TEST REPORT

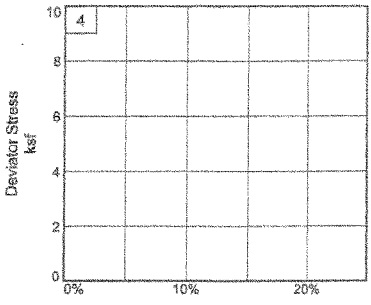
MACTEC ENGINEERING AND CONSULTING, INC.

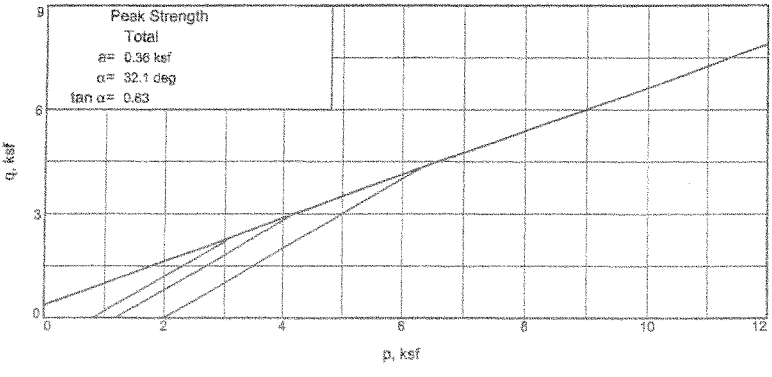
Tested By: MC **Checked By:** Kajri Sukhwani











Client: Nodarse and Associates
Project: Material Testing-Nodarse
Sample Number: UU-95% 14 day cured
Project No.: 6738-05-4573

Reviewed By _____ MACTEC Engineering and Consulting, Inc.

Tested By: MC _____ **Checked By:** _____

TRIAXIAL COMPRESSION TEST 7/14/2005
Unconsolidated Undrained 9:00 AM

Date:	6-28-05
Client:	Nodarse and Associates
Project:	Material Testing-Nodarse
Project No.:	6738-05-4573
Sample Number:	UU-95% 14 day cured
Description:	Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments
Remarks:	sample moist cured 14 days
Type of Sample:	remold

Specific Gravity=2.762 **LL=** **PL=** **PI=**

Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	125.860		413.600
Moisture content: Dry soil+tare, gms.	112.030		364.200
Moisture content: Tare, gms.	24.930		50.800
Moisture, %	15.9	22.8	15.8
Moist specimen weight, gms.	1217.6		
Diameter, in.	2.84	2.83	
Area, in.²	6.33	6.28	
Height, in.	6.05	6.02	
Net decrease in height, in.		0.03	
Wet Density, pcf	121.0	129.9	
Dry density, pcf	104.4	105.8	
Void ratio	0.6508	0.6304	
Saturation, %	67.4	100.0	

Test Readings for Specimen No. 1

Primary load ring constant = .463 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Cell pressure = 5.60 psi (0.81 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 4.52 ksf **at reading no.** 27

MACTEC Engineering and Consulting, Inc.

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	0.81	0.81	1.00		0.81
1	0.0010	12.0	5.6	0.0	0.13	0.81	0.93	1.16		0.87
2	0.0050	65.0	30.1	0.1	0.69	0.81	1.50	1.85		1.15
3	0.0100	95.0	44.0	0.2	1.01	0.81	1.81	2.25		1.31
4	0.0150	124.0	57.4	0.2	1.31	0.81	2.12	2.63		1.46
5	0.0200	145.0	67.1	0.3	1.53	0.81	2.34	2.90		1.57
6	0.0250	165.0	76.4	0.4	1.74	0.81	2.55	3.16		1.68
7	0.0300	183.0	84.7	0.5	1.93	0.81	2.74	3.40		1.77
8	0.0350	195.0	90.3	0.6	2.06	0.81	2.86	3.55		1.84
9	0.0400	208.0	96.3	0.7	2.19	0.81	3.00	3.72		1.90
10	0.0450	222.0	102.8	0.7	2.34	0.81	3.14	3.90		1.98
11	0.0500	233.0	107.9	0.8	2.45	0.81	3.26	4.04		2.03
12	0.0750	280.0	129.6	1.2	2.93	0.81	3.74	4.64		2.27
13	0.1000	303.0	140.3	1.7	3.16	0.81	3.97	4.92		2.39
14	0.1250	327.0	151.4	2.1	3.40	0.81	4.20	5.21		2.51
15	0.1500	347.0	160.7	2.5	3.59	0.81	4.40	5.45		2.60
16	0.1750	359.0	166.2	2.9	3.70	0.81	4.51	5.59		2.66
17	0.2000	371.0	171.8	3.3	3.81	0.81	4.61	5.72		2.71
18	0.2500	389.0	180.1	4.1	3.96	0.81	4.76	5.91		2.78
19	0.3000	401.0	185.7	5.0	4.04	0.81	4.85	6.01		2.83
20	0.4000	415.0	192.1	6.6	4.11	0.81	4.92	6.10		2.86
21	0.5000	427.0	197.7	8.3	4.16	0.81	4.96	6.15		2.88
22	0.6000	445.0	206.0	10.0	4.25	0.81	5.06	6.27		2.93
23	0.7000	460.0	213.0	11.6	4.31	0.81	5.12	6.35		2.96
24	0.8000	475.0	219.9	13.3	4.37	0.81	5.18	6.42		2.99
25	0.9000	497.0	230.1	14.9	4.49	0.81	5.29	6.56		3.05
26	1.0000	509.0	235.7	16.6	4.51	0.81	5.31	6.59		3.06
27	1.1000	521.0	241.2	18.3	4.52	0.81	5.33	6.60		3.07

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	128.130		1393.600
Moisture content: Dry soil+tare, gms.	114.500		1212.300
Moisture content: Tare, gms.	30.350		116.100
Moisture, %	16.2	21.7	16.5
Moist specimen weight, gms.	1276.8		
Diameter, in.	2.84	2.84	
Area, in.²	6.33	6.32	
Height, in.	6.15	6.14	
Net decrease in height, in.		0.01	
Wet Density, pcf	124.9	131.2	
Dry density, pcf	107.4	107.8	
Void ratio	0.6047	0.6000	
Saturation, %	74.0	100.0	

Test Readings for Specimen No. 2

Primary load ring constant = .463 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Cell pressure = 8.30 psi (1.20 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 6.16 ksf at reading no. 25

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	1.20	1.20	1.00		1.20
1	0.0010	33.0	15.3	0.0	0.35	1.20	1.54	1.29		1.37
2	0.0050	77.0	35.7	0.1	0.81	1.20	2.01	1.68		1.60
3	0.0100	127.0	58.8	0.2	1.34	1.20	2.53	2.12		1.86
4	0.0150	164.0	75.9	0.2	1.73	1.20	2.92	2.44		2.06
5	0.0200	193.0	89.4	0.3	2.03	1.20	3.22	2.70		2.21
6	0.0250	220.0	101.9	0.4	2.31	1.20	3.51	2.93		2.35
7	0.0300	242.0	112.0	0.5	2.54	1.20	3.73	3.12		2.46
8	0.0350	262.0	121.3	0.6	2.75	1.20	3.94	3.30		2.57
9	0.0400	287.0	132.9	0.7	3.01	1.20	4.20	3.52		2.70
10	0.0450	298.0	138.0	0.7	3.12	1.20	4.31	3.61		2.75
11	0.0500	310.0	143.5	0.8	3.24	1.20	4.44	3.71		2.82
12	0.0750	380.0	175.9	1.2	3.96	1.20	5.15	4.31		3.17
13	0.1000	426.0	197.2	1.6	4.42	1.20	5.61	4.70		3.40
14	0.1250	460.0	213.0	2.0	4.75	1.20	5.95	4.98		3.57
15	0.1500	497.0	230.1	2.4	5.11	1.20	6.31	5.28		3.75
16	0.2000	534.0	247.2	3.3	5.45	1.20	6.64	5.56		3.92
17	0.2500	558.0	258.4	4.1	5.64	1.20	6.84	5.72		4.02
18	0.3000	575.0	266.2	4.9	5.77	1.20	6.96	5.83		4.08
19	0.4000	592.0	274.1	6.5	5.84	1.20	7.03	5.88		4.11
20	0.5000	619.0	286.6	8.1	6.00	1.20	7.19	6.02		4.19
21	0.6000	631.0	292.2	9.8	6.00	1.20	7.20	6.02		4.20
22	0.7000	653.0	302.3	11.4	6.10	1.20	7.30	6.11		4.25
23	0.8000	667.0	308.8	13.0	6.12	1.20	7.31	6.12		4.25
24	0.9000	681.0	315.3	14.6	6.13	1.20	7.32	6.13		4.26

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Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
25	1.0000	698.0	323.2	16.3	6.16	1.20	7.36	6.16		4.28
26	1.1000	708.0	327.8	17.9	6.13	1.20	7.32	6.13		4.26

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	122.870		333.740
Moisture content: Dry soil+tare, gms.	110.280		294.900
Moisture content: Tare, gms.	30.550		52.160
Moisture, %	15.8	21.9	16.0
Moist specimen weight, gms.	1411.4		
Diameter, in.	2.84	2.84	
Area, in.²	6.33	6.33	
Height, in.	6.83	6.83	
Net decrease in height, in.		0.00	
Wet Density, pcf	124.3	131.0	
Dry density, pcf	107.3	107.5	
Void ratio	0.6066	0.6044	
Saturation, %	71.9	100.0	

Test Readings for Specimen No. 3

Primary load ring constant = .463 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Cell pressure = 13.90 psi (2.00 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 8.58 ksf at reading no. 24

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.00	2.00	1.00		2.00
1	0.0010	27.0	12.5	0.0	0.28	2.00	2.29	1.14		2.14
2	0.0050	78.0	36.1	0.1	0.82	2.00	2.82	1.41		2.41
3	0.0100	146.0	67.6	0.1	1.54	2.00	3.54	1.77		2.77
4	0.0150	192.0	88.9	0.2	2.02	2.00	4.02	2.01		3.01
5	0.0200	233.0	107.9	0.3	2.45	2.00	4.45	2.22		3.23
6	0.0250	265.0	122.7	0.4	2.78	2.00	4.78	2.39		3.39
7	0.0300	295.0	136.6	0.4	3.09	2.00	5.10	2.55		3.55
8	0.0350	323.0	149.5	0.5	3.39	2.00	5.39	2.69		3.69
9	0.0400	347.0	160.7	0.6	3.63	2.00	5.64	2.82		3.82
10	0.0450	368.0	170.4	0.7	3.85	2.00	5.85	2.92		3.93
11	0.0500	393.0	182.0	0.7	4.11	2.00	6.11	3.05		4.06
12	0.0750	503.0	232.9	1.1	5.24	2.00	7.24	3.62		4.62
13	0.1000	553.0	256.0	1.5	5.74	2.00	7.74	3.87		4.87
14	0.1250	609.0	282.0	1.8	6.30	2.00	8.30	4.15		5.15
15	0.1500	655.0	303.3	2.2	6.75	2.00	8.75	4.37		5.38
16	0.1750	693.0	320.9	2.6	7.11	2.00	9.11	4.55		5.56
17	0.2000	724.0	335.2	2.9	7.40	2.00	9.40	4.70		5.70
18	0.2500	768.0	355.6	3.7	7.79	2.00	9.80	4.89		5.90

MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 3

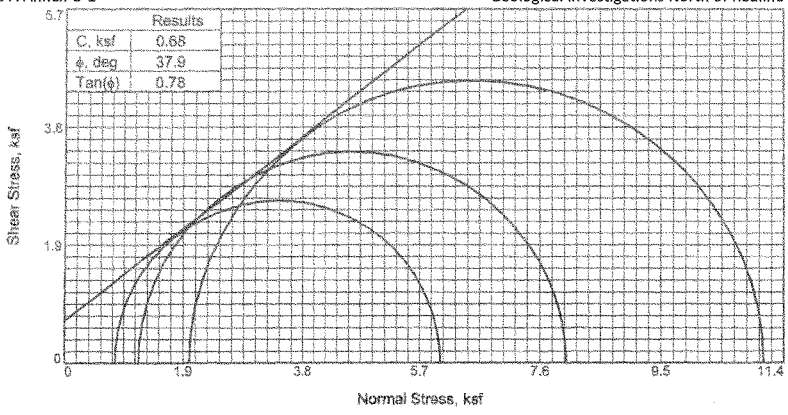
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
19	0.3000	802.0	371.3	4.4	8.08	2.00	10.08	5.04		6.04
20	0.3500	832.0	385.2	5.1	8.32	2.00	10.32	5.15		6.16
21	0.4000	852.0	394.5	5.9	8.45	2.00	10.45	5.22		6.23
22	0.5000	878.0	406.5	7.3	8.57	2.00	10.57	5.28		6.29
23	0.6000	890.0	412.1	8.8	8.55	2.00	10.55	5.27		6.28
24	0.7000	908.0	420.4	10.3	8.58	2.00	10.59	5.29		6.29
25	0.8000	917.0	424.6	11.7	8.53	2.00	10.53	5.26		6.27
26	0.9000	927.0	429.2	13.2	8.48	2.00	10.48	5.24		6.24
27	1.0000	940.0	435.2	14.6	8.45	2.00	10.45	5.22		6.23
28	1.1000	959.0	444.0	16.1	8.47	2.00	10.48	5.23		6.24

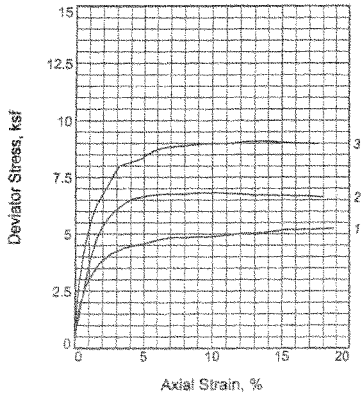
14 day cured specimens Nodarse 6738-05-4576-02 cast 6-28-05 tested 7-12-05

Tube Weight 766.2 Tube Diameter (in) 2.84 Area 6.334702 Length 25.2 cm maximum density
9.92126 in 115.5

weight w/ sample and tube	weight sample (lb)	distance to sample (cm)	sample length (in)	sample volume (cuft)	sample wet density (lb/cuft)	wet wt w/ can	dry wt. w/ can	can wt	% moisture	sample dry density (lb/cuft)	% compactio n	
2104.2	2.95	9.6	6.14	0.0225	131.0	113.5	101.81	30.01	16.28	112.67026	97.6	not used
2167.1	3.04	7.6	6.85	0.0251	121.2	113.5	101.81	30.01	16.28	104.25353	90.3	1 A 13.9
2116.2	3.12	7	7.17	0.0263	118.8	113.21	100.4	24.66	16.24	102.24443	88.5	2 A 5.6
2239.3	3.28	6.7	7.28	0.0267	122.8	122.11	108.3	30.67	16.29	105.60068	91.4	not used
2167.1	2.67	5.8	6.06	0.0222	120.2	122.11	108.3	30.67	16.29	103.35942	89.5	3 A 8.3
2117.2	2.98	6	6.77	0.0248	120.0	139.16	124.28	32.03	16.15	103.34316	89.5	4
2123.1	3.10	7.5	6.97	0.0255	121.5	113.61	101.08	25.01	16.31	104.43123	90.4	5
2212.1	3.00	10.4	6.73	0.0247	121.6	93.51	84.65	30.01	16.22	104.67476	90.6	6
2141.8	3.02	8.3	6.65	0.0244	123.8	93.51	84.65	30.01	16.22	106.52016	92.2	not used
1998.1	2.71	10.4	5.79	0.0212	127.9	114.19	102.03	30.03	15.98	110.25697	95.5	1
2047.1	2.83	9.4	6.02	0.0221	128.0	116.86	104.03	24.89	15.88	110.41974	95.6	2
2057.1	2.85	9.7	6.10	0.0224	127.2	120.13	104.5	30.09	16.20	109.5015	94.8	3
2103.1	3.15	10	6.77	0.0248	126.8	122.87	110.28	30.05	15.79	109.50206	94.8	4
2060.1	2.90	9.3	6.26	0.0229	126.2	117.66	102.03	24.71	16.18	108.64164	94.1	5
1998.1	2.70	10.4	5.83	0.0214	126.2	106.74	90.32	31.52	16.32	108.49796	93.9	6

App A Annex G-1 Geological Investigations North of Redline





Sample No.		1	2	3
Initial	Water Content,	16.0	16.3	16.2
	Dry Density, pcf	108.3	108.0	107.6
	Saturation,	74.5	75.5	74.1
	Void Ratio	0.5925	0.5972	0.6030
	Diameter, in.	2.84	2.84	2.84
	Height, in.	5.87	6.15	6.28
At Test	Water Content,	20.9	21.3	20.9
	Dry Density, pcf	109.4	108.5	109.3
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.5763	0.5886	0.5770
	Diameter, in.	2.83	2.83	2.82
	Height, in.	5.85	6.14	6.25
Strain rate, in./min.		0.05	0.05	0.05
Back Pressure, ksf		0.0	0.0	0.0
Cell Pressure, ksf		0.8	1.2	2.0
Fail. Stress, ksf		5.2	6.8	9.1
Ult. Stress, ksf				
σ_1 Failure, ksf		6.0	8.0	11.1
σ_3 Failure, ksf		0.8	1.2	2.0

Type of Test: Unconsolidated Undrained
Sample Type: remold
Description: Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments

Specific Gravity= 2.762
Remarks: Samples moist cured 14 days

Reviewed By _____

Client: Nodarse and Associates

Project: Material Testing-Nodarse

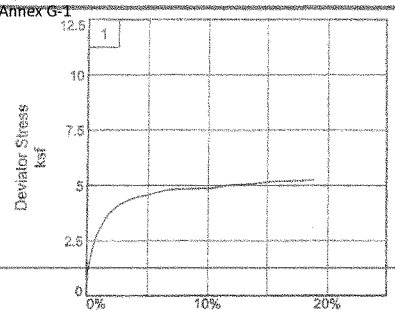
Sample Number: UU-95% 14 day cured

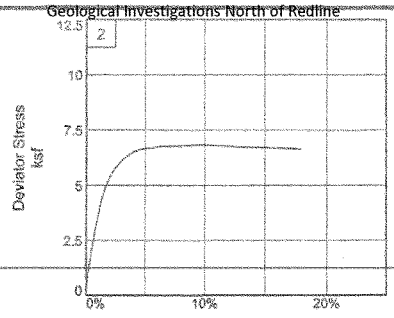
Proj. No.: 6728-05-4573 **Date:** 6-28-05

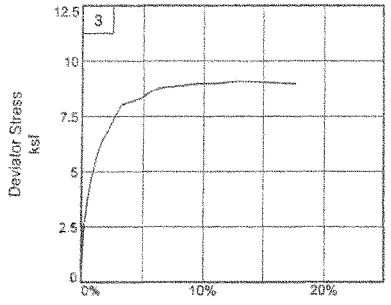
TRIAXIAL SHEAR TEST REPORT

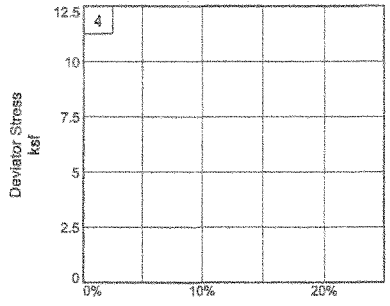
MACTEC ENGINEERING AND CONSULTING, INC.

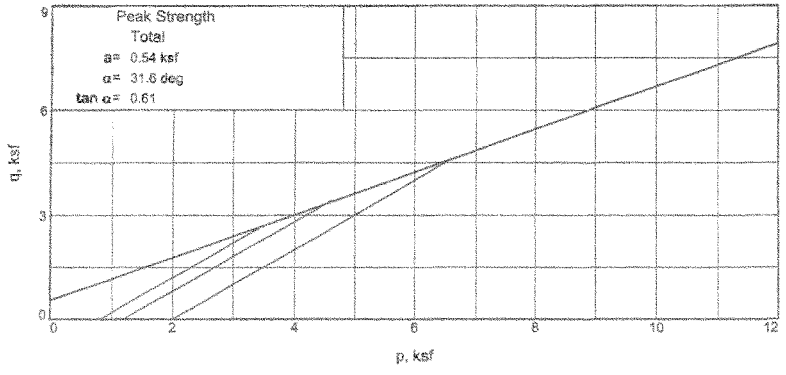
Tested By: MC **Checked By:** Rajni Sukhwani











Client: Nodarse and Associates
Project: Material Testing-Nodarse
Sample Number: UU-95% 14 day cured
Project No.: 6738-05-4573 **Reviewed By** _____ MACTEC Engineering and Consulting, Inc.

Tested By: MC **Checked By:** _____

TRIAXIAL COMPRESSION TEST

Unconsolidated Undrained

7/14/2005
9:03 AM

Date:	6-28-05
Client:	Nodarse and Associates
Project:	Material Testing-Nodarse
Project No.:	6738-05-4573
Sample Number:	UU-95% 14 day cured
Description:	Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments
Remarks:	Samples moist cured 14 days
Type of Sample:	remold
Specific Gravity=2.762	LL= PL= PI=
Test Method:	COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	114.180		409.300
Moisture content: Dry soil+tare, gms.	102.630		360.550
Moisture content: Tare, gms.	30.350		52.330
Moisture, %	16.0	20.9	15.8
Moist specimen weight, gms.	1225.7		
Diameter, in.	2.84	2.83	
Area, in.²	6.33	6.29	
Height, in.	5.87	5.85	
Net decrease in height, in.		0.02	
Wet Density, pcf	125.6	132.2	
Dry density, pcf	108.3	109.4	
Void ratio	0.5925	0.5763	
Saturation, %	74.5	100.0	

Test Readings for Specimen No. 1

Primary load ring constant = .463 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Cell pressure = 5.60 psi (0.81 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 5.23 ksf at reading no. 28

MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	0.81	0.81	1.00		0.81
1	0.0010	31.0	14.4	0.0	0.33	0.81	1.13	1.41		0.97
2	0.0050	78.0	36.1	0.1	0.83	0.81	1.63	2.02		1.22
3	0.0100	121.0	56.0	0.2	1.28	0.81	2.09	2.59		1.45
4	0.0150	148.0	68.5	0.3	1.56	0.81	2.37	2.94		1.59
5	0.0200	172.0	79.6	0.3	1.82	0.81	2.62	3.25		1.71
6	0.0250	193.0	89.4	0.4	2.04	0.81	2.84	3.53		1.82
7	0.0300	210.0	97.2	0.5	2.21	0.81	3.02	3.75		1.91
8	0.0350	227.0	105.1	0.6	2.39	0.81	3.20	3.97		2.00
9	0.0400	243.0	112.5	0.7	2.56	0.81	3.36	4.17		2.09
10	0.0450	256.0	118.5	0.8	2.69	0.81	3.50	4.34		2.15
11	0.0500	268.0	124.1	0.9	2.82	0.81	3.62	4.49		2.21
12	0.0750	312.0	144.5	1.3	3.26	0.81	4.07	5.05		2.44
13	0.1000	352.0	163.0	1.7	3.67	0.81	4.47	5.55		2.64
14	0.1250	374.0	173.2	2.1	3.88	0.81	4.69	5.81		2.75
15	0.1500	397.0	183.8	2.6	4.10	0.81	4.91	6.08		2.86
16	0.1750	410.0	189.8	3.0	4.21	0.81	5.02	6.23		2.91
17	0.2000	425.0	196.8	3.4	4.35	0.81	5.16	6.39		2.98
18	0.2500	443.0	205.1	4.3	4.49	0.81	5.30	6.57		3.05
19	0.3000	455.0	210.7	5.1	4.57	0.81	5.38	6.67		3.09
20	0.3500	473.0	219.0	6.0	4.71	0.81	5.52	6.84		3.16
21	0.4000	486.0	225.0	6.8	4.80	0.81	5.60	6.95		3.21
22	0.5000	500.0	231.5	8.5	4.85	0.81	5.65	7.01		3.23
23	0.6000	512.0	237.1	10.3	4.87	0.81	5.68	7.04		3.24
24	0.7000	537.0	248.6	12.0	5.01	0.81	5.82	7.21		3.31
25	0.8000	552.0	255.6	13.7	5.05	0.81	5.86	7.26		3.33
26	0.9000	577.0	267.2	15.4	5.17	0.81	5.98	7.42		3.39
27	1.0000	591.0	273.6	17.1	5.19	0.81	6.00	7.44		3.40
28	1.1000	608.0	281.5	18.8	5.23	0.81	6.04	7.49		3.42

MACTEC Engineering and Consulting, Inc.

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	106.780		858.900
Moisture content: Dry soil+tare, gms.	96.220		771.000
Moisture content: Tare, gms.	31.520		230.300
Moisture, %	16.3	21.3	16.3
Moist specimen weight, gms.	1284.2		
Diameter, in.	2.84	2.83	
Area, in.²	6.33	6.31	
Height, in.	6.15	6.14	
Net decrease in height, in.		0.01	
Wet Density, pcf	125.6	131.7	
Dry density, pcf	108.0	108.5	
Void ratio	0.5972	0.5886	
Saturation, %	75.5	100.0	

Test Readings for Specimen No. 2

Primary load ring constant = .463 lbs. per input unit

Membrane modulus = 0.124105 kN/cm²

Membrane thickness = 0.02 cm

Cell pressure = 8.30 psi (1.20 ksf)

Back pressure = 0.00 psi (0.00 ksf)

Strain rate, in./min. = 0.05

Fail. Stress = 6.81 ksf at reading no. 23

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	1.20	1.20	1.00		1.20
1	0.0010	37.0	17.1	0.0	0.39	1.20	1.59	1.33		1.39
2	0.0050	62.0	28.7	0.1	0.65	1.20	1.85	1.55		1.52
3	0.0100	90.0	41.7	0.2	0.95	1.20	2.14	1.79		1.67
4	0.0150	115.0	53.2	0.2	1.21	1.20	2.41	2.01		1.80
5	0.0200	141.0	65.3	0.3	1.48	1.20	2.68	2.24		1.94
6	0.0250	168.0	77.8	0.4	1.77	1.20	2.96	2.48		2.08
7	0.0300	195.0	90.3	0.5	2.05	1.20	3.24	2.71		2.22
8	0.0350	220.0	101.9	0.6	2.31	1.20	3.51	2.93		2.35
9	0.0400	245.0	113.4	0.7	2.57	1.20	3.77	3.15		2.48
10	0.0450	270.0	125.0	0.7	2.83	1.20	4.03	3.37		2.61
11	0.0500	296.0	137.0	0.8	3.10	1.20	4.30	3.59		2.75
12	0.0750	395.0	182.9	1.2	4.12	1.20	5.32	4.45		3.26
13	0.1000	467.0	216.2	1.6	4.85	1.20	6.05	5.06		3.62
14	0.1250	520.0	240.8	2.0	5.38	1.20	6.58	5.50		3.89
15	0.1500	555.0	257.0	2.4	5.72	1.20	6.91	5.79		4.05
16	0.1750	584.0	270.4	2.9	5.99	1.20	7.19	6.01		4.19
17	0.2000	608.0	281.5	3.3	6.21	1.20	7.41	6.20		4.30
18	0.2500	644.0	298.2	4.1	6.53	1.20	7.72	6.46		4.46
19	0.3000	660.0	305.6	4.9	6.63	1.20	7.83	6.55		4.51
20	0.3500	672.0	311.1	5.7	6.69	1.20	7.89	6.60		4.54
21	0.4000	685.0	317.2	6.5	6.76	1.20	7.96	6.66		4.58
22	0.5000	697.0	322.7	8.1	6.76	1.20	7.96	6.66		4.58
23	0.6000	715.0	331.0	9.8	6.81	1.20	8.01	6.70		4.60
24	0.7000	724.0	335.2	11.4	6.78	1.20	7.97	6.67		4.58

MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
25	0.8000	731.0	338.5	13.0	6.72	1.20	7.91	6.62		4.55
26	0.9000	743.0	344.0	14.7	6.70	1.20	7.89	6.60		4.54
27	1.0000	755.0	349.6	16.3	6.68	1.20	7.87	6.59		4.53
28	1.1000	764.0	353.7	17.9	6.62	1.20	7.82	6.54		4.51

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	137.560		345.130
Moisture content: Dry soil+tare, gms.	122.830		304.400
Moisture content: Tare, gms.	31.780		49.860
Moisture, %	16.2	20.9	16.0
Moist specimen weight, gms.	1305.0		
Diameter, in.	2.84	2.82	
Area, in.²	6.33	6.27	
Height, in.	6.28	6.25	
Net decrease in height, in.		0.03	
Wet Density, pcf	125.0	132.2	
Dry density, pcf	107.6	109.3	
Void ratio	0.6030	0.5770	
Saturation, %	74.1	100.0	

Test Readings for Specimen No. 3

Primary load ring constant = .463 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Cell pressure = 13.90 psi (2.00 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 9.09 ksf at reading no. 24

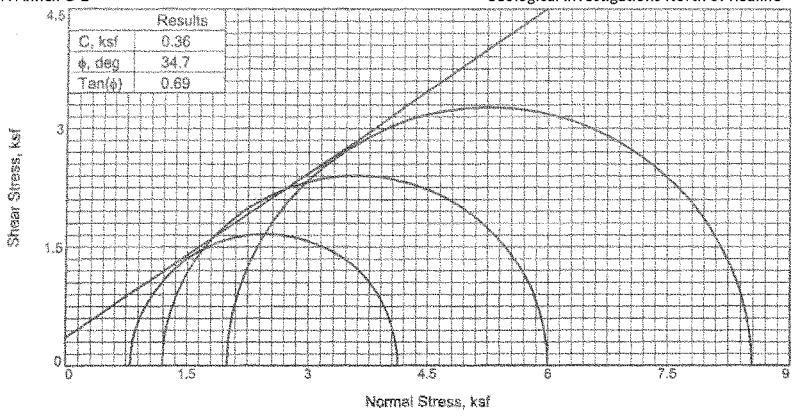
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.00	2.00	1.00		2.00
1	0.0010	32.0	14.8	0.0	0.34	2.00	2.34	1.17		2.17
2	0.0050	118.0	54.6	0.1	1.25	2.00	3.26	1.63		2.63
3	0.0100	188.0	87.0	0.2	2.00	2.00	4.00	2.00		3.00
4	0.0150	242.0	112.0	0.2	2.57	2.00	4.57	2.28		3.29
5	0.0200	281.0	130.1	0.3	2.98	2.00	4.98	2.49		3.49
6	0.0250	313.0	144.9	0.4	3.32	2.00	5.32	2.66		3.66
7	0.0300	348.0	161.1	0.5	3.68	2.00	5.69	2.84		3.84
8	0.0350	375.0	173.6	0.6	3.97	2.00	5.97	2.98		3.99
9	0.0400	403.0	186.6	0.6	4.26	2.00	6.26	3.13		4.13
10	0.0450	427.0	197.7	0.7	4.51	2.00	6.51	3.25		4.26
11	0.0500	446.0	206.5	0.8	4.71	2.00	6.71	3.35		4.36
12	0.0750	538.0	249.1	1.2	5.66	2.00	7.66	3.83		4.83
13	0.1000	605.0	280.1	1.6	6.33	2.00	8.34	4.16		5.17
14	0.1250	645.0	298.6	2.0	6.73	2.00	8.73	4.36		5.36
15	0.1500	690.0	319.5	2.4	7.17	2.00	9.17	4.58		5.58
16	0.1750	737.0	341.2	2.8	7.62	2.00	9.62	4.81		5.81

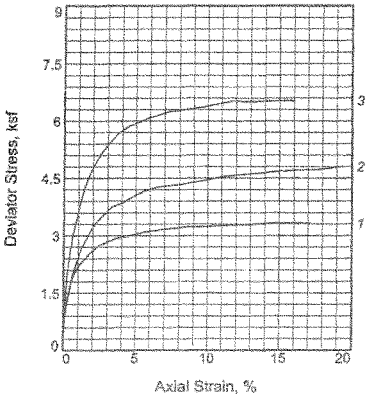
MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
17	0.2000	777.0	359.8	3.2	8.00	2.00	10.00	5.00		6.00
18	0.3000	821.0	380.1	4.8	8.32	2.00	10.32	5.15		6.16
19	0.3500	858.0	397.3	5.6	8.62	2.00	10.62	5.31		6.31
20	0.4000	882.0	408.4	6.4	8.78	2.00	10.79	5.39		6.39
21	0.5000	907.0	419.9	8.0	8.88	2.00	10.88	5.44		6.44
22	0.6000	934.0	432.4	9.6	8.98	2.00	10.98	5.49		6.49
23	0.7000	951.0	440.3	11.2	8.98	2.00	10.99	5.49		6.49
24	0.8000	980.0	453.7	12.8	9.09	2.00	11.09	5.54		6.55
25	0.9000	995.0	460.7	14.4	9.06	2.00	11.06	5.53		6.53
26	1.0000	1008.0	466.7	16.0	9.01	2.00	11.01	5.50		6.51
27	1.1000	1023.0	473.6	17.6	8.97	2.00	10.97	5.48		6.49

App A Annex G-1 Geological Investigations North of Redline





Sample No.		1	2	3
Initial	Water Content,	16.2	16.3	16.3
	Dry Density, pcf	103.5	100.7	101.2
	Saturation,	67.4	63.2	63.8
	Void Ratio	0.6653	0.7122	0.7043
	Diameter, in.	2.84	2.84	2.84
	Height, in.	7.04	6.19	6.89
At Test	Water Content,	22.7	25.2	24.9
	Dry Density, pcf	105.9	101.7	102.2
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.6278	0.6957	0.6866
	Diameter, in.	2.82	2.83	2.83
	Height, in.	6.99	6.17	6.87
Strain rate, in./min.		0.05	0.05	0.05
Back Pressure, ksf		0.00	0.00	0.00
Cell Pressure, ksf		0.81	1.20	2.00
Fail. Stress, ksf		3.32	4.80	6.53
Ult. Stress, ksf				
σ_1 Failure, ksf		4.13	6.00	8.53
σ_3 Failure, ksf		0.81	1.20	2.00

Type of Test: Unconsolidated Undrained
Sample Type: Remolded
Description: Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments

Specific Gravity= 2.762
Remarks: Specimen cured 14 days after molding.

Reviewed By _____

Client: Nodarse and Associates

Project: Material Testing-Nodarse

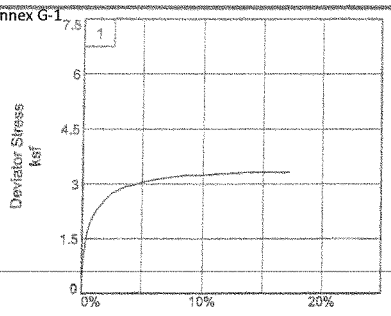
Sample Number: UU-90% 14 day cured

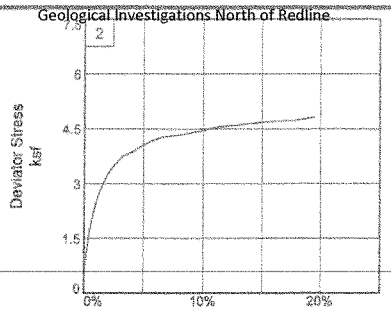
Proj. No.: 6738-05-4573 **Date:** 7/12/05

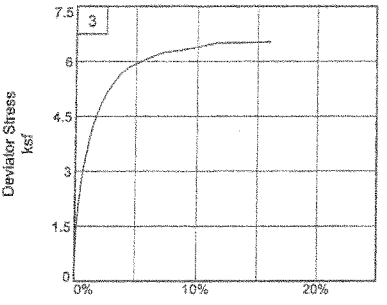
TRIAXIAL SHEAR TEST REPORT

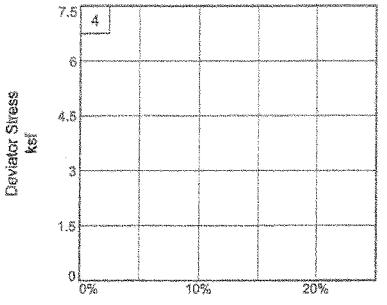
MACTEC ENGINEERING AND CONSULTING, INC.

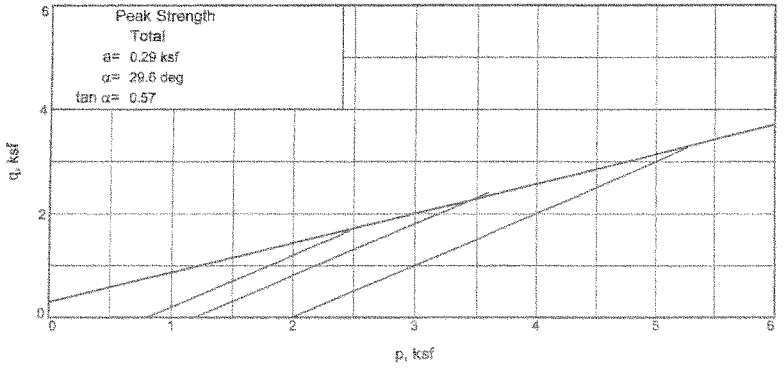
Tested By: MC **Checked By:** Rajni Sukhwani











Client: Nodarse and Associates
Project: Material Testing-Nodarse
Sample Number: UU-90% 14 day cured
Project No.: 6738-05-4573

Reviewed By _____ MACTEC Engineering and Consulting, Inc.

Tested By: MC _____ **Checked By:** _____

TRIAXIAL COMPRESSION TEST 7/14/2005
Unconsolidated Undrained 8:57 AM

Date:	7/12/05
Client:	Nodarse and Associates
Project:	Material Testing-Nodarse
Project No.:	6738-05-4573
Sample Number:	UU-90% 14 day cured
Description:	Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments
Remarks:	Specimen cured 14 days after molding.
Type of Sample:	Remolded
Specific Gravity=2.762	LL= PL= PI=
Test Method:	COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	112.710		1524.300
Moisture content: Dry soil+tare, gms.	100.400		1328.800
Moisture content: Tare, gms.	24.580		115.390
Moisture, %	16.2	22.7	16.1
Moist specimen weight, gms.	1408.9		
Diameter, in.	2.84	2.82	
Area, in.²	6.33	6.24	
Height, in.	7.04	6.99	
Net decrease in height, in.		0.05	
Wet Density, pcf	120.4	130.0	
Dry density, pcf	103.5	105.9	
Void ratio	0.6653	0.6278	
Saturation, %	67.4	100.0	

Test Readings for Specimen No. 1

Primary load ring constant = .463 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Cell pressure = 5.60 psi (0.81 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 3.32 ksf at reading no. 28

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Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	0.81	0.81	1.00		0.81
1	0.0010	20.0	9.3	0.0	0.21	0.81	1.02	1.26		0.91
2	0.0050	56.0	25.9	0.1	0.60	0.81	1.40	1.74		1.11
3	0.0100	93.0	43.1	0.1	0.99	0.81	1.80	2.23		1.30
4	0.0150	107.0	49.5	0.2	1.14	0.81	1.95	2.41		1.38
5	0.0200	130.0	60.2	0.3	1.39	0.81	2.19	2.72		1.50
6	0.0250	142.0	65.7	0.4	1.51	0.81	2.32	2.87		1.56
7	0.0300	153.0	70.8	0.4	1.63	0.81	2.43	3.02		1.62
8	0.0350	164.0	75.9	0.5	1.74	0.81	2.55	3.16		1.68
9	0.0400	173.0	80.1	0.6	1.84	0.81	2.64	3.28		1.73
10	0.0450	178.0	82.4	0.6	1.89	0.81	2.70	3.34		1.75
11	0.0500	186.0	86.1	0.7	1.97	0.81	2.78	3.45		1.79
12	0.0750	210.0	97.2	1.1	2.22	0.81	3.03	3.75		1.92
13	0.1000	226.0	104.6	1.4	2.38	0.81	3.19	3.95		2.00
14	0.1250	241.0	111.6	1.8	2.53	0.81	3.34	4.14		2.07
15	0.1500	253.0	117.1	2.1	2.65	0.81	3.45	4.28		2.13
16	0.1750	264.0	122.2	2.5	2.75	0.81	3.56	4.41		2.18
17	0.2000	270.0	125.0	2.9	2.80	0.81	3.61	4.48		2.21
18	0.2500	283.0	131.0	3.6	2.92	0.81	3.72	4.62		2.26
19	0.3000	290.0	134.3	4.3	2.97	0.81	3.77	4.68		2.29
20	0.3500	299.0	138.4	5.0	3.03	0.81	3.84	4.76		2.32
21	0.4000	307.0	142.1	5.7	3.09	0.81	3.90	4.84		2.35
22	0.5000	319.0	147.7	7.2	3.16	0.81	3.97	4.92		2.39
23	0.6000	330.0	152.8	8.6	3.22	0.81	4.03	5.00		2.42
24	0.7000	336.0	155.6	10.0	3.23	0.81	4.04	5.01		2.42
25	0.8000	345.0	159.7	11.4	3.26	0.81	4.07	5.05		2.44
26	0.9000	353.0	163.4	12.9	3.29	0.81	4.09	5.08		2.45
27	1.0000	362.0	167.6	14.3	3.31	0.81	4.12	5.11		2.46
28	1.1000	369.0	170.8	15.7	3.32	0.81	4.13	5.12		2.47
29	1.2000	375.0	173.6	17.2	3.32	0.81	4.13	5.12		2.47

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	122.110		1314.500
Moisture content: Dry soil+tare, gms.	109.300		1148.100
Moisture content: Tare, gms.	30.670		108.500
Moisture, %	16.3	25.2	16.0
Moist specimen weight, gms.	1205.4		
Diameter, in.	2.84	2.83	
Area, in.²	6.33	6.29	
Height, in.	6.19	6.17	
Net decrease in height, in.		0.02	
Wet Density, pcf	117.1	127.3	
Dry density, pcf	100.7	101.7	
Void ratio	0.7122	0.6957	
Saturation, %	63.2	100.0	

Test Readings for Specimen No. 2

Primary load ring constant = .463 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Cell pressure = 8.30 psi (1.20 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 4.80 ksf at reading no. 29

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	1.20	1.20	1.00		1.20
1	0.0010	25.0	11.6	0.0	0.26	1.20	1.46	1.22		1.33
2	0.0050	68.0	31.5	0.1	0.72	1.20	1.91	1.60		1.56
3	0.0100	94.0	43.5	0.2	0.99	1.20	2.19	1.83		1.69
4	0.0150	113.0	52.3	0.2	1.19	1.20	2.39	2.00		1.79
5	0.0200	130.0	60.2	0.3	1.37	1.20	2.57	2.15		1.88
6	0.0250	146.0	67.6	0.4	1.54	1.20	2.74	2.29		1.97
7	0.0300	162.0	75.0	0.5	1.71	1.20	2.90	2.43		2.05
8	0.0350	175.0	81.0	0.6	1.84	1.20	3.04	2.54		2.12
9	0.0400	189.0	87.5	0.6	1.99	1.20	3.18	2.66		2.19
10	0.0450	197.0	91.2	0.7	2.07	1.20	3.27	2.73		2.23
11	0.0500	208.0	96.3	0.8	2.19	1.20	3.38	2.83		2.29
12	0.0750	255.0	118.1	1.2	2.67	1.20	3.86	3.23		2.53
13	0.1000	285.0	132.0	1.6	2.97	1.20	4.17	3.49		2.68
14	0.1250	313.0	144.9	2.0	3.25	1.20	4.44	3.72		2.82
15	0.1500	332.0	153.7	2.4	3.43	1.20	4.63	3.87		2.91
16	0.1750	348.0	161.1	2.8	3.58	1.20	4.78	4.00		2.99
17	0.2000	364.0	168.5	3.2	3.73	1.20	4.93	4.12		3.06
18	0.2500	379.0	175.5	4.1	3.85	1.20	5.05	4.22		3.12
19	0.3000	399.0	184.7	4.9	4.02	1.20	5.22	4.36		3.21
20	0.3500	416.0	192.6	5.7	4.16	1.20	5.35	4.48		3.27
21	0.4000	430.0	199.1	6.5	4.26	1.20	5.46	4.56		3.33
22	0.5000	445.0	206.0	8.1	4.33	1.20	5.53	4.62		3.36
23	0.6000	463.0	214.4	9.7	4.43	1.20	5.62	4.70		3.41
24	0.7000	484.0	224.1	11.3	4.55	1.20	5.74	4.80		3.47

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Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
25	0.8000	499.0	231.0	13.0	4.60	1.20	5.80	4.85		3.50
26	0.9000	515.0	238.4	14.6	4.66	1.20	5.85	4.90		3.53
27	1.0000	530.0	245.4	16.2	4.70	1.20	5.90	4.94		3.55
28	1.1000	542.0	250.9	17.8	4.72	1.20	5.91	4.95		3.55
29	1.2000	563.0	260.7	19.4	4.80	1.20	6.00	5.02		3.60

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	113.500		1454.600
Moisture content: Dry soil+tare, gms.	101.810		1264.500
Moisture content: Tare, gms.	30.010		106.100
Moisture, %	16.3	24.9	16.4
Moist specimen weight, gms.	1347.8		
Diameter, in.	2.84	2.83	
Area, in.²	6.33	6.29	
Height, in.	6.89	6.87	
Net decrease in height, in.		0.02	
Wet Density, pcf	117.6	127.6	
Dry density, pcf	101.2	102.2	
Void ratio	0.7043	0.6866	
Saturation, %	63.8	100.0	

Test Readings for Specimen No. 3

Primary load ring constant = .463 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Cell pressure = 13.90 psi (2.00 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 6.53 ksf at reading no. 28

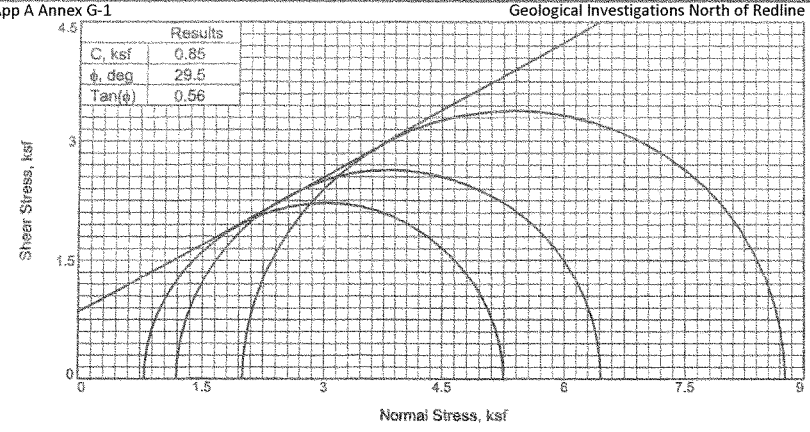
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.00	2.00	1.00		2.00
1	0.0010	15.0	6.9	0.0	0.16	2.00	2.16	1.08		2.08
2	0.0050	87.0	40.3	0.1	0.92	2.00	2.92	1.46		2.46
3	0.0100	138.0	63.9	0.1	1.46	2.00	3.46	1.73		2.73
4	0.0150	170.0	78.7	0.2	1.80	2.00	3.80	1.90		2.90
5	0.0200	193.0	89.4	0.3	2.04	2.00	4.04	2.02		3.02
6	0.0250	217.0	100.5	0.4	2.29	2.00	4.29	2.14		3.15
7	0.0300	237.0	109.7	0.4	2.50	2.00	4.50	2.25		3.25
8	0.0350	255.0	118.1	0.5	2.69	2.00	4.69	2.34		3.35
9	0.0400	272.0	125.9	0.6	2.87	2.00	4.87	2.43		3.43
10	0.0450	290.0	134.3	0.7	3.05	2.00	5.06	2.53		3.53
11	0.0500	300.0	138.9	0.7	3.16	2.00	5.16	2.58		3.58
12	0.0750	360.0	166.7	1.1	3.77	2.00	5.78	2.89		3.89
13	0.1000	408.0	188.9	1.5	4.26	2.00	6.26	3.13		4.13
14	0.1250	445.0	206.0	1.8	4.63	2.00	6.63	3.31		4.32
15	0.1500	473.0	219.0	2.2	4.90	2.00	6.91	3.45		4.45

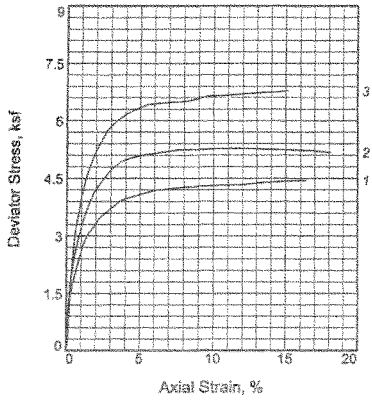
MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
16	0.1750	497.0	230.1	2.5	5.13	2.00	7.13	3.56		4.57
17	0.2000	517.0	239.4	2.9	5.32	2.00	7.32	3.66		4.66
18	0.2500	553.0	256.0	3.6	5.65	2.00	7.65	3.82		4.83
19	0.3000	576.0	266.7	4.4	5.84	2.00	7.84	3.92		4.92
20	0.3500	591.0	273.6	5.1	5.94	2.00	7.95	3.97		4.97
21	0.4000	607.0	281.0	5.8	6.06	2.00	8.06	4.03		5.03
22	0.5000	635.0	294.0	7.3	6.24	2.00	8.24	4.12		5.12
23	0.6000	652.0	301.9	8.7	6.31	2.00	8.31	4.15		5.15
24	0.7000	672.0	311.1	10.2	6.40	2.00	8.40	4.20		5.20
25	0.8000	695.0	321.8	11.7	6.51	2.00	8.51	4.25		5.26
26	0.9000	706.0	326.9	13.1	6.50	2.00	8.50	4.25		5.25
27	1.0000	720.0	333.4	14.6	6.52	2.00	8.52	4.26		5.26
28	1.1000	734.0	339.8	16.0	6.53	2.00	8.53	4.26		5.27

App A Annex G-1 Geological Investigations North of Redline





Sample No.		1	2	3
Initial	Water Content,	16.2	16.2	16.3
	Dry Density, pcf	105.1	105.8	103.8
	Saturation,	69.7	71.1	68.1
	Void Ratio	0.6400	0.6298	0.6609
	Diameter, in.	2.85	2.84	2.84
	Height, in.	6.72	6.65	7.32
At Test	Water Content,	22.6	22.2	22.4
	Dry Density, pcf	106.1	106.9	106.5
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.6254	0.6136	0.6189
	Diameter, in.	2.84	2.83	2.82
	Height, in.	6.70	6.63	7.26
Strain rate, in./min.		0.05	0.05	0.05
Back Pressure, ksf		0.00	0.00	0.00
Cell Pressure, ksf		0.81	1.20	2.00
Fail. Stress, ksf		4.44	5.27	6.77
Ult. Stress, ksf				
σ_1 Failure, ksf		5.24	6.47	8.77
σ_3 Failure, ksf		0.81	1.20	2.00

Type of Test: Unconsolidated Undrained
Sample Type: remold
Description: Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments

Specific Gravity= 2.762
Remarks: Specimens cured 14 days

Reviewed By _____

Client: Nodarse and Associates

Project: Material Testing-Nodarse

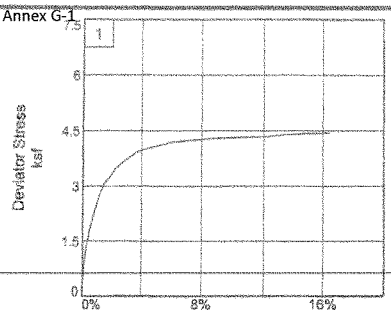
Sample Number: UU-90%-14 day cured

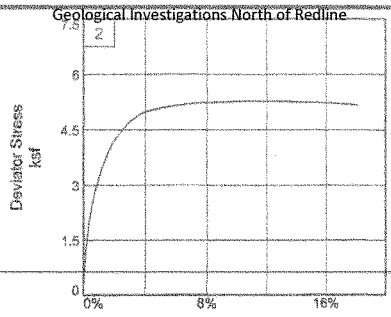
Proj. No.: 6738-05-4573 **Date:** 6-28-05

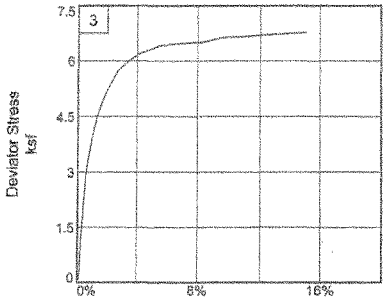
TRIAXIAL SHEAR TEST REPORT

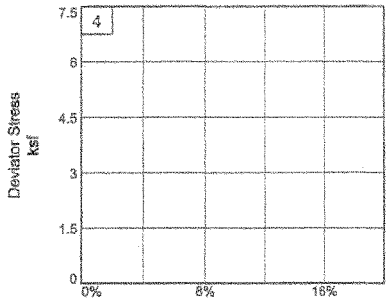
MACTEC ENGINEERING AND CONSULTING, INC.

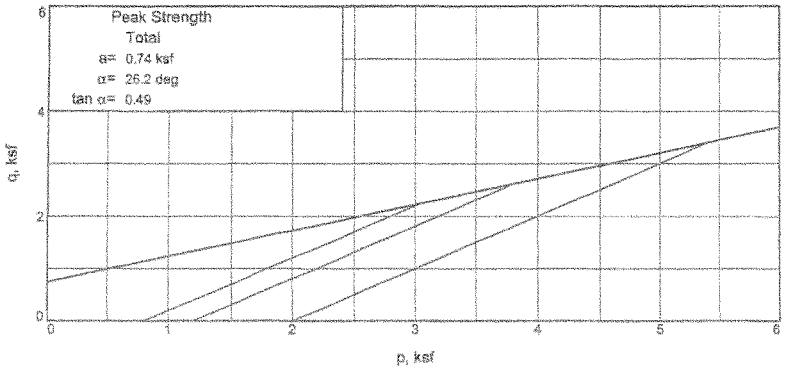
Tested By: MC **Checked By:** Rajni Sukhwani











Client: Nodarse and Associates
Project: Material Testing-Nodarse
Sample Number: UU-90%-14 day cured
Project No.: 6738-05-4573

Reviewed By _____ MACTEC Engineering and Consulting, Inc.

Tested By: MC _____ **Checked By:** _____

TRIAXIAL COMPRESSION TEST

Unconsolidated Undrained

7/14/2005
8:59 AM

Date:	6-28-05
Client:	Nodarse and Associates
Project:	Material Testing-Nodarse
Project No.:	6738-05-4573
Sample Number:	UU-90%-14 day cured
Description:	Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments
Remarks:	Specimens cured 14 days
Type of Sample:	remold

Specific Gravity=2.762 **LL=** **PL=** **PI=**

Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	139.180		1490.700
Moisture content: Dry soil+tare, gms.	124.280		1300.300
Moisture content: Tare, gms.	32.030		116.290
Moisture, %	16.2	22.6	16.1
Moist specimen weight, gms.	1374.2		
Diameter, in.	2.85	2.84	
Area, in.^{2}	6.38	6.34	
Height, in.	6.72	6.70	
Net decrease in height, in.		0.02	
Wet Density, pcf	122.1	130.1	
Dry density, pcf	105.1	106.1	
Void ratio	0.6400	0.6254	
Saturation, %	69.7	100.0	

Test Readings for Specimen No. 1

Primary load ring constant = .463 lbs. per input unit
Membrane modulus = 0.124105 kN/cm^2
Membrane thickness = 0.02 cm
Cell pressure = 5.60 psi (0.81 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 4.44 ksf at reading no. 27

MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	0.81	0.81	1.00		0.81
1	0.0010	23.0	10.6	0.0	0.24	0.81	1.05	1.30		0.93
2	0.0050	68.0	31.5	0.1	0.71	0.81	1.52	1.89		1.16
3	0.0100	98.0	45.4	0.1	1.03	0.81	1.84	2.28		1.32
4	0.0150	117.0	54.2	0.2	1.23	0.81	2.03	2.52		1.42
5	0.0200	138.0	63.9	0.3	1.45	0.81	2.25	2.79		1.53
6	0.0250	150.0	69.5	0.4	1.57	0.81	2.38	2.95		1.59
7	0.0300	167.0	77.3	0.4	1.75	0.81	2.55	3.17		1.68
8	0.0350	178.0	82.4	0.5	1.86	0.81	2.67	3.31		1.74
9	0.0400	188.0	87.0	0.6	1.96	0.81	2.77	3.44		1.79
10	0.0450	201.0	93.1	0.7	2.10	0.81	2.91	3.60		1.86
11	0.0500	211.0	97.7	0.7	2.20	0.81	3.01	3.73		1.91
12	0.0750	262.0	121.3	1.1	2.72	0.81	3.53	4.38		2.17
13	0.1000	296.0	137.0	1.5	3.07	0.81	3.87	4.80		2.34
14	0.1250	314.0	145.4	1.9	3.24	0.81	4.05	5.02		2.43
15	0.1500	337.0	156.0	2.2	3.46	0.81	4.27	5.30		2.54
16	0.2000	364.0	168.5	3.0	3.71	0.81	4.52	5.60		2.66
17	0.2500	388.0	179.6	3.7	3.93	0.81	4.73	5.87		2.77
18	0.3000	400.0	185.2	4.5	4.02	0.81	4.82	5.98		2.81
19	0.3500	411.0	190.3	5.2	4.10	0.81	4.90	6.08		2.85
20	0.4000	423.0	195.8	6.0	4.18	0.81	4.99	6.19		2.90
21	0.5000	436.0	201.9	7.5	4.24	0.81	5.05	6.26		2.93
22	0.6000	448.0	207.4	9.0	4.29	0.81	5.09	6.32		2.95
23	0.7000	458.0	212.1	10.4	4.31	0.81	5.12	6.35		2.96
24	0.8000	467.0	216.2	11.9	4.32	0.81	5.13	6.36		2.97
25	0.9000	482.0	223.2	13.4	4.39	0.81	5.19	6.44		3.00
26	1.0000	494.0	228.7	14.9	4.42	0.81	5.22	6.48		3.02
27	1.1000	505.0	233.8	16.4	4.44	0.81	5.24	6.50		3.03

Parameters for Specimen No. 2			
Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	93.510		1475.100
Moisture content: Dry soil+tare, gms.	84.650		1284.200
Moisture content: Tare, gms.	30.010		115.500
Moisture, %	16.2	22.2	16.3
Moist specimen weight, gms.	1359.6		
Diameter, in.	2.84	2.83	
Area, in.²	6.33	6.29	
Height, in.	6.65	6.63	
Net decrease in height, in.		0.02	
Wet Density, pcf	123.0	130.6	
Dry density, pcf	105.8	106.9	
Void ratio	0.6298	0.6136	
Saturation, %	71.1	100.0	

Test Readings for Specimen No. 2

Primary load ring constant = .463 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Cell pressure = 8.30 psi (1.20 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 5.27 ksf at reading no. 25

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	1.20	1.20	1.00		1.20
1	0.0010	20.0	9.3	0.0	0.21	1.20	1.41	1.18		1.30
2	0.0050	63.0	29.2	0.1	0.67	1.20	1.86	1.56		1.53
3	0.0100	110.0	50.9	0.2	1.16	1.20	2.36	1.97		1.78
4	0.0150	141.0	65.3	0.2	1.49	1.20	2.69	2.25		1.94
5	0.0200	166.0	76.9	0.3	1.75	1.20	2.95	2.47		2.07
6	0.0250	190.0	88.0	0.4	2.01	1.20	3.20	2.68		2.20
7	0.0300	205.0	94.9	0.5	2.16	1.20	3.36	2.81		2.28
8	0.0350	223.0	103.2	0.5	2.35	1.20	3.55	2.97		2.37
9	0.0400	239.0	110.7	0.6	2.52	1.20	3.71	3.11		2.45
10	0.0450	254.0	117.6	0.7	2.67	1.20	3.87	3.24		2.53
11	0.0500	268.0	124.1	0.8	2.82	1.20	4.01	3.36		2.60
12	0.0750	322.0	149.1	1.1	3.37	1.20	4.57	3.82		2.88
13	0.1000	365.0	169.0	1.5	3.81	1.20	5.00	4.19		3.10
14	0.1250	398.0	184.3	1.9	4.14	1.20	5.33	4.46		3.26
15	0.1500	420.0	194.5	2.3	4.35	1.20	5.54	4.64		3.37
16	0.1750	440.0	203.7	2.6	4.54	1.20	5.73	4.80		3.46
17	0.2000	460.0	213.0	3.0	4.73	1.20	5.92	4.95		3.56
18	0.2500	485.0	224.6	3.8	4.94	1.20	6.14	5.14		3.67
19	0.3000	498.0	230.6	4.5	5.04	1.20	6.23	5.21		3.71
20	0.3500	508.0	235.2	5.3	5.10	1.20	6.29	5.27		3.74
21	0.4000	517.0	239.4	6.0	5.15	1.20	6.34	5.31		3.77
22	0.5000	534.0	247.2	7.5	5.23	1.20	6.43	5.38		3.81
23	0.6000	544.0	251.9	9.1	5.24	1.20	6.44	5.39		3.82
24	0.7000	556.0	257.4	10.6	5.27	1.20	6.46	5.41		3.83

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Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
25	0.8000	566.0	262.1	12.1	5.27	1.20	6.47	5.41		3.83
26	0.9000	574.0	265.8	13.6	5.26	1.20	6.45	5.40		3.82
27	1.0000	582.0	269.5	15.1	5.24	1.20	6.43	5.38		3.81
28	1.1000	590.0	273.2	16.6	5.21	1.20	6.41	5.36		3.80
29	1.2000	596.0	275.9	18.1	5.17	1.20	6.37	5.33		3.78

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	115.810		358.120
Moisture content: Dry soil+tare, gms.	103.080		315.900
Moisture content: Tare, gms.	25.010		54.860
Moisture, %	16.3	22.4	16.2
Moist specimen weight, gms.	1469.7		
Diameter, in.	2.84	2.82	
Area, in.^{2}	6.33	6.23	
Height, in.	7.32	7.26	
Net decrease in height, in.		0.06	
Wet Density, pcf	120.7	130.4	
Dry density, pcf	103.8	106.5	
Void ratio	0.6609	0.6189	
Saturation, %	68.1	100.0	

Test Readings for Specimen No. 3

Primary load ring constant = .463 lbs. per input unit

Membrane modulus = 0.124105 kN/cm^2

Membrane thickness = 0.02 cm

Cell pressure = 13.90 psi (2.00 ksf)

Back pressure = 0.00 psi (0.00 ksf)

Strain rate, in./min. = 0.05

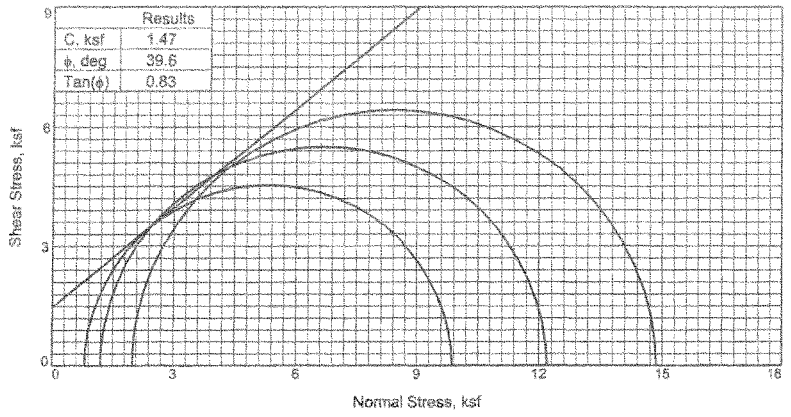
Fail. Stress = 6.77 ksf at reading no. 27

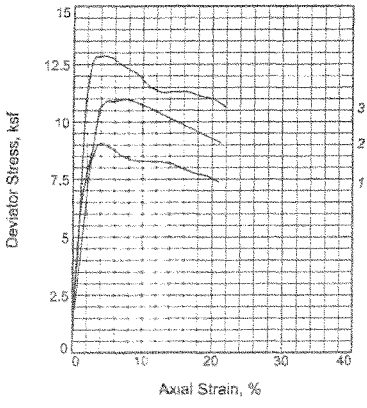
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.0	0.0	0.0	0.00	2.00	2.00	1.00		2.00
1	0.0010	5.0	2.3	0.0	0.05	2.00	2.06	1.03		2.03
2	0.0050	7.0	3.2	0.1	0.07	2.00	2.08	1.04		2.04
3	0.0100	25.0	11.6	0.1	0.27	2.00	2.27	1.13		2.14
4	0.0150	80.0	37.0	0.2	0.85	2.00	2.86	1.43		2.43
5	0.0200	123.0	56.9	0.3	1.31	2.00	3.31	1.66		2.66
6	0.0250	175.0	81.0	0.3	1.87	2.00	3.87	1.93		2.94
7	0.0300	209.0	96.8	0.4	2.23	2.00	4.23	2.11		3.12
8	0.0350	240.0	111.1	0.5	2.56	2.00	4.56	2.28		3.28
9	0.0400	268.0	124.1	0.6	2.85	2.00	4.86	2.43		3.43
10	0.0450	290.0	134.3	0.6	3.09	2.00	5.09	2.54		3.54
11	0.0500	307.0	142.1	0.7	3.26	2.00	5.27	2.63		3.63
12	0.0750	378.0	175.0	1.0	4.01	2.00	6.01	3.00		4.00
13	0.1000	432.0	200.0	1.4	4.56	2.00	6.56	3.28		4.28
14	0.1250	470.0	217.6	1.7	4.95	2.00	6.95	3.47		4.47
15	0.1500	501.0	232.0	2.1	5.25	2.00	7.25	3.62		4.63

MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
16	0.2000	552.0	255.6	2.8	5.75	2.00	7.75	3.87		4.88
17	0.2500	580.0	268.5	3.4	6.00	2.00	8.00	4.00		5.00
18	0.3000	603.0	279.2	4.1	6.19	2.00	8.19	4.09		5.10
19	0.3500	618.0	286.1	4.8	6.30	2.00	8.30	4.15		5.15
20	0.4000	634.0	293.5	5.5	6.41	2.00	8.42	4.20		5.21
21	0.5000	649.0	300.5	6.9	6.47	2.00	8.47	4.23		5.24
22	0.6000	662.0	306.5	8.3	6.50	2.00	8.50	4.25		5.25
23	0.7000	686.0	317.6	9.6	6.64	2.00	8.64	4.32		5.32
24	0.8000	699.0	323.6	11.0	6.66	2.00	8.66	4.33		5.33
25	0.9000	715.0	331.0	12.4	6.71	2.00	8.71	4.35		5.35
26	1.0000	730.0	338.0	13.8	6.74	2.00	8.74	4.37		5.37
27	1.1000	745.0	344.9	15.2	6.77	2.00	8.77	4.38		5.39





Sample No.		1	2	3
Initial	Water Content,	15.3	15.3	15.4
	Dry Density, pcf	109.5	109.0	108.9
	Saturation,	73.5	72.7	72.9
	Void Ratio	0.5754	0.5818	0.5835
	Diameter, in.	2.84	2.84	2.84
	Height, in.	5.73	5.23	5.47
At Test	Water Content,	20.4	19.3	20.3
	Dry Density, pcf	110.4	112.5	110.5
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.5622	0.5331	0.5601
	Diameter, in.	2.83	2.81	2.83
	Height, in.	5.71	5.18	5.44
Strain rate, in./min.		0.05	0.05	0.05
Back Pressure, ksf		0.0	0.0	0.0
Cell Pressure, ksf		0.8	1.2	2.0
Fail. Stress, ksf		9.1	11.0	12.8
Ult. Stress, ksf				
σ_1 Failure, ksf		9.9	12.2	14.8
σ_3 Failure, ksf		0.8	1.2	2.0

Type of Test: Unconsolidated Undrained
Sample Type: remold
Description: Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments

Specific Gravity= 2.762
Remarks:

Reviewed By _____

Client: Nodarse and Associates

Project: Material Testing-Nodarse

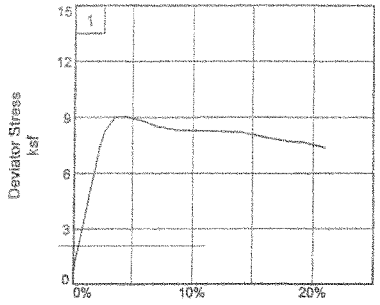
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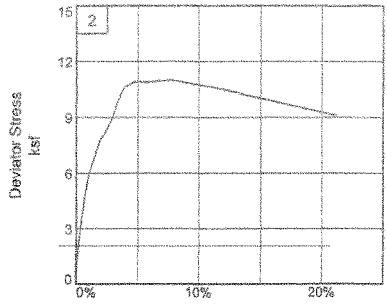
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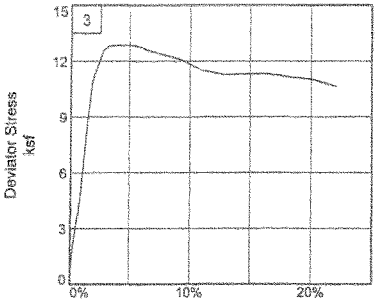
TRIAXIAL SHEAR TEST REPORT

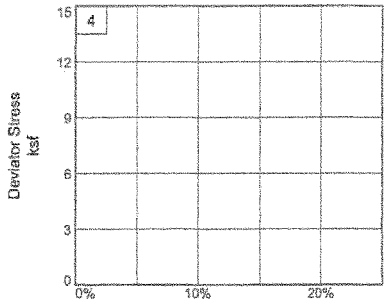
MACTEC ENGINEERING AND CONSULTING, INC.

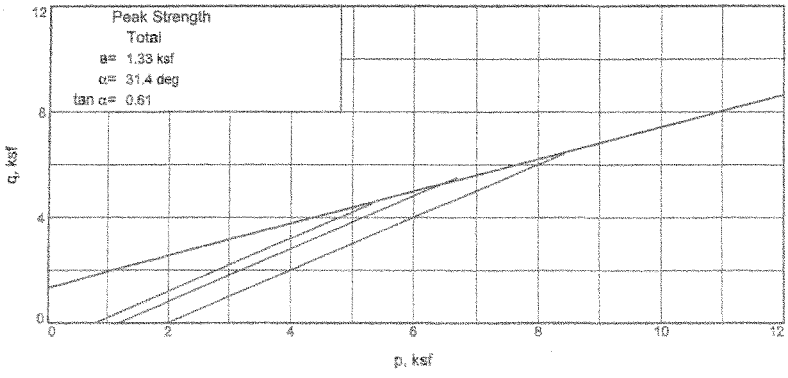
Tested By: mc **Checked By:** Rajni Sukhwani











Client: Nodarse and Associates
Project: Material Testing-Nodarse
Sample Number: UU-95%-B
Project No.: 6738-05-4573

Reviewed By _____ MACTEC Engineering and Consulting, Inc.

Tested By: mc _____ **Checked By:** _____

TRIAXIAL COMPRESSION TEST

Unconsolidated Undrained

6/15/2005
10:46 AM

Date:	6-11-05
Client:	Nodarse and Associates
Project:	Material Testing-Nodarse
Project No.:	6738-05-4573
Sample Number:	UU-95%-B
Description:	Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments
Remarks:	
Type of Sample:	remold

Specific Gravity=2.762 **LL=** **PL=** **PI=**

Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	188.130		1340.400
Moisture content: Dry soil+tare, gms.	170.070		1175.600
Moisture content: Tare, gms.	52.090		116.300
Moisture, %	15.3	20.4	15.6
Moist specimen weight, gms.	1202.5		
Diameter, in.	2.84	2.83	
Area, in.²	6.33	6.30	
Height, in.	5.73	5.71	
Net decrease in height, in.		0.02	
Wet Density, pcf	126.2	132.8	
Dry density, pcf	109.5	110.4	
Void ratio	0.5754	0.5622	
Saturation, %	73.5	100.0	

Test Readings for Specimen No. 1

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Cell pressure = 5.60 psi (0.81 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 9.05 ksf at reading no. 17

MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	0.81	0.81	1.00		0.81
1	0.0010	5.00	16.6	0.0	0.38	0.81	1.19	1.47		1.00
2	0.0050	12.00	39.8	0.1	0.91	0.81	1.71	2.13		1.26
3	0.0100	18.00	59.6	0.2	1.36	0.81	2.17	2.69		1.49
4	0.0150	22.00	72.9	0.3	1.66	0.81	2.47	3.06		1.64
5	0.0200	26.00	86.1	0.4	1.96	0.81	2.77	3.43		1.79
6	0.0250	29.00	96.1	0.4	2.19	0.81	2.99	3.71		1.90
7	0.0300	32.00	106.0	0.5	2.41	0.81	3.22	3.99		2.01
8	0.0350	36.00	119.3	0.6	2.71	0.81	3.52	4.36		2.16
9	0.0400	40.00	132.5	0.7	3.01	0.81	3.81	4.73		2.31
10	0.0450	43.00	142.5	0.8	3.23	0.81	4.04	5.01		2.42
11	0.0500	47.00	155.7	0.9	3.53	0.81	4.33	5.38		2.57
12	0.0750	65.00	215.3	1.3	4.86	0.81	5.66	7.02		3.24
13	0.1000	81.00	268.4	1.8	6.03	0.81	6.83	8.47		3.82
14	0.1250	100.00	331.3	2.2	7.41	0.81	8.21	10.19		4.51
15	0.1500	112.00	371.1	2.6	8.26	0.81	9.07	11.24		4.94
16	0.2000	123.00	407.5	3.5	8.99	0.81	9.80	12.15		5.30
17	0.2500	125.00	414.1	4.4	9.05	0.81	9.86	12.23		5.33
18	0.3000	124.00	410.8	5.3	8.90	0.81	9.70	12.03		5.26
19	0.3500	123.00	407.5	6.1	8.74	0.81	9.55	11.84		5.18
20	0.4000	121.00	400.9	7.0	8.52	0.81	9.33	11.57		5.07
21	0.5000	120.00	397.6	8.8	8.29	0.81	9.10	11.28		4.95
22	0.6000	122.00	404.2	10.5	8.27	0.81	9.08	11.25		4.94
23	0.7000	124.00	410.8	12.3	8.24	0.81	9.05	11.22		4.93
24	0.8000	126.00	417.4	14.0	8.21	0.81	9.01	11.18		4.91
25	0.9000	125.00	414.1	15.8	7.98	0.81	8.78	10.89		4.79
26	1.0000	124.00	410.8	17.5	7.75	0.81	8.55	10.61		4.68
27	1.1000	125.00	414.1	19.3	7.64	0.81	8.45	10.48		4.63
28	1.2000	123.00	407.5	21.0	7.36	0.81	8.17	10.13		4.49

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	188.130		1199.200
Moisture content: Dry soil+tare, gms.	170.070		1052.600
Moisture content: Tare, gms.	52.090		115.000
Moisture, %	15.3	19.3	15.6
Moist specimen weight, gms.	1093.1		
Diameter, in.	2.84	2.81	
Area, in.²	6.33	6.20	
Height, in.	5.23	5.18	
Net decrease in height, in.		0.05	
Wet Density, pcf	125.7	134.2	
Dry density, pcf	109.0	112.5	
Void ratio	0.5818	0.5331	
Saturation, %	72.7	100.0	

Test Readings for Specimen No. 2

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Cell pressure = 8.30 psi (1.20 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 11.00 ksf at reading no. 20

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	1.20	1.20	1.00		1.20
1	0.0010	5.00	16.6	0.0	0.38	1.20	1.58	1.32		1.39
2	0.0050	16.00	53.0	0.1	1.23	1.20	2.42	2.03		1.81
3	0.0100	26.00	86.1	0.2	2.00	1.20	3.19	2.67		2.19
4	0.0150	35.00	116.0	0.3	2.68	1.20	3.88	3.25		2.54
5	0.0200	41.00	135.8	0.4	3.14	1.20	4.34	3.63		2.77
6	0.0250	49.00	162.3	0.5	3.75	1.20	4.95	4.14		3.07
7	0.0300	54.00	178.9	0.6	4.13	1.20	5.32	4.45		3.26
8	0.0350	61.00	202.1	0.7	4.66	1.20	5.85	4.90		3.52
9	0.0400	66.00	218.7	0.8	5.04	1.20	6.23	5.21		3.71
10	0.0450	70.00	231.9	0.9	5.34	1.20	6.53	5.46		3.86
11	0.0500	76.00	251.8	1.0	5.79	1.20	6.98	5.84		4.09
12	0.0750	90.00	298.2	1.4	6.82	1.20	8.02	6.71		4.61
13	0.1000	103.00	341.2	1.9	7.77	1.20	8.96	7.50		5.08
14	0.1250	110.00	364.4	2.4	8.25	1.20	9.45	7.91		5.32
15	0.1500	119.00	394.2	2.9	8.89	1.20	10.08	8.43		5.64
16	0.1750	132.00	437.3	3.4	9.81	1.20	11.00	9.21		6.10
17	0.2000	143.00	473.8	3.9	10.57	1.20	11.77	9.85		6.48
18	0.2500	149.00	493.6	4.8	10.90	1.20	12.10	10.12		6.65
19	0.3000	150.00	497.0	5.8	10.87	1.20	12.06	10.09		6.63
20	0.4000	155.00	513.5	7.7	11.00	1.20	12.19	10.20		6.69
21	0.5000	155.00	513.5	9.7	10.77	1.20	11.96	10.01		6.58
22	0.6000	155.00	513.5	11.6	10.54	1.20	11.73	9.82		6.46
23	0.7000	154.00	510.2	13.5	10.24	1.20	11.44	9.57		6.32
24	0.8000	153.00	506.9	15.5	9.95	1.20	11.14	9.32		6.17

MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
25	0.9000	152.00	503.6	17.4	9.66	1.20	10.85	9.08		6.02
26	1.0000	151.00	500.3	19.3	9.37	1.20	10.56	8.84		5.88
27	1.1000	150.00	497.0	21.3	9.08	1.20	10.28	8.60		5.74

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	189.370		1256.200
Moisture content: Dry soil+tare, gms.	171.030		1099.800
Moisture content: Tare, gms.	51.890		98.400
Moisture, %	15.4	20.3	15.6
Moist specimen weight, gms.	1142.9		
Diameter, in.	2.84	2.83	
Area, in.^{2}	6.33	6.27	
Height, in.	5.47	5.44	
Net decrease in height, in.		0.03	
Wet Density, pcf	125.7	132.9	
Dry density, pcf	108.9	110.5	
Void ratio	0.5835	0.5601	
Saturation, %	72.9	100.0	

Test Readings for Specimen No. 3

Load ring constant = 3.313 lbs. per input unit

Membrane modulus = 0.124105 kN/cm^2

Membrane thickness = 0.02 cm

Cell pressure = 13.90 psi (2.00 ksf)

Back pressure = 0.00 psi (0.00 ksf)

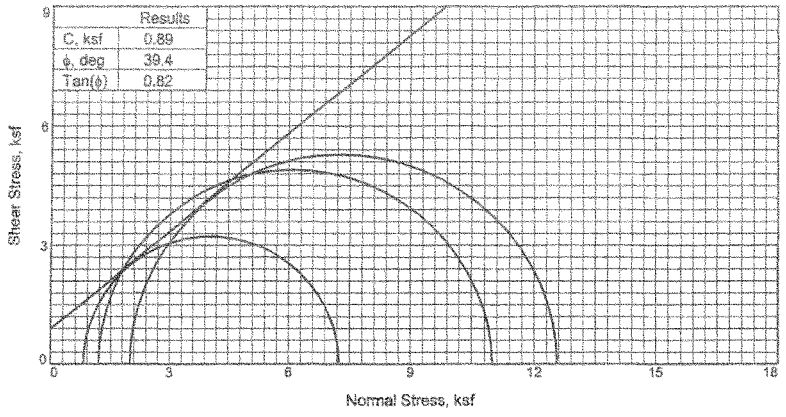
Strain rate, in./min. = 0.05

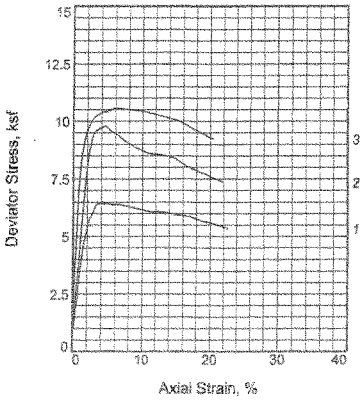
Fail. Stress = 12.84 ksf at reading no. 17

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	2.00	2.00	1.00		2.00
1	0.0010	6.00	19.9	0.0	0.46	2.00	2.46	1.23		2.23
2	0.0050	17.00	56.3	0.1	1.29	2.00	3.29	1.65		2.65
3	0.0100	24.00	79.5	0.2	1.82	2.00	3.82	1.91		2.91
4	0.0150	30.00	99.4	0.3	2.28	2.00	4.28	2.14		3.14
5	0.0200	36.00	119.3	0.4	2.73	2.00	4.73	2.36		3.37
6	0.0250	41.00	135.8	0.5	3.10	2.00	5.11	2.55		3.55
7	0.0300	46.00	152.4	0.6	3.48	2.00	5.48	2.74		3.74
8	0.0350	51.00	169.0	0.6	3.85	2.00	5.86	2.93		3.93
9	0.0400	57.00	188.8	0.7	4.30	2.00	6.31	3.15		4.15
10	0.0450	64.00	212.0	0.8	4.83	2.00	6.83	3.41		4.42
11	0.0500	72.00	238.5	0.9	5.43	2.00	7.43	3.71		4.71
12	0.0750	112.00	371.1	1.4	8.40	2.00	10.40	5.20		6.20
13	0.1000	146.00	483.7	1.8	10.90	2.00	12.90	6.45		7.45
14	0.1500	170.00	563.2	2.8	12.57	2.00	14.58	7.28		8.29
15	0.1750	174.00	576.5	3.2	12.81	2.00	14.81	7.40		8.41
16	0.2000	175.00	579.8	3.7	12.82	2.00	14.82	7.41		8.41
17	0.2500	177.00	586.4	4.6	12.84	2.00	14.85	7.42		8.42

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
18	0.3000	178.00	589.7	5.5	12.79	2.00	14.79	7.39		8.40
19	0.3500	177.00	586.4	6.4	12.60	2.00	14.60	7.29		8.30
20	0.4000	176.00	583.1	7.3	12.40	2.00	14.40	7.20		8.20
21	0.5000	175.00	579.8	9.2	12.09	2.00	14.09	7.04		8.05
22	0.6000	170.00	563.2	11.0	11.51	2.00	13.51	6.75		7.75
23	0.7000	170.00	563.2	12.9	11.27	2.00	13.27	6.63		7.64
24	0.8000	174.00	576.5	14.7	11.29	2.00	13.29	6.64		7.65
25	0.9000	178.00	589.7	16.5	11.30	2.00	13.30	6.65		7.65
26	1.0000	179.00	593.0	18.4	11.11	2.00	13.12	6.55		7.56
27	1.1000	181.00	599.7	20.2	10.98	2.00	12.99	6.49		7.49
28	1.2000	179.00	593.0	22.0	10.61	2.00	12.61	6.30		7.31





Sample No.		1	2	3
Initial	Water Content,	16.6	16.1	16.8
	Dry Density, pcf	104.1	103.5	104.6
	Saturation,	70.0	66.7	71.5
	Void Ratio	0.6567	0.6651	0.6486
	Diameter, in.	2.84	2.84	2.84
	Height, in.	5.32	5.50	5.90
At Test	Water Content,	22.9	23.3	22.8
	Dry Density, pcf	105.6	105.0	105.7
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.6334	0.6425	0.6310
	Diameter, in.	2.83	2.83	2.83
	Height, in.	5.29	5.47	5.88
Strain rate, in./min.		0.05	0.05	0.05
Back Pressure, ksf		0.0	0.0	0.0
Cell Pressure, ksf		0.8	1.2	2.0
Fail. Stress, ksf		6.4	9.8	10.6
Ult. Stress, ksf				
σ_1 Failure, ksf		7.3	11.0	12.6
σ_3 Failure, ksf		0.8	1.2	2.0

Type of Test: Unconsolidated Undrained
Sample Type: remolded
Description: Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments

Specific Gravity= 2.762
Remarks:

Reviewed By _____

Client: Nodarse and Associates

Project: Material Testing-Nodarse

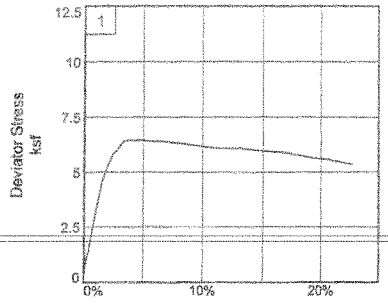
Sample Number: UU-90%-B

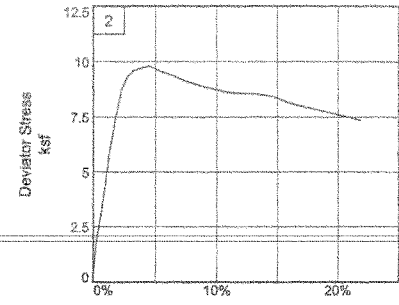
Proj. No.: 6738-05-4573 **Date:** 6-10-05

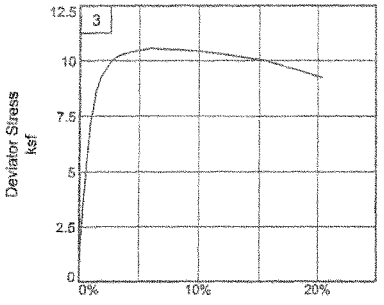
TRIAXIAL SHEAR TEST REPORT

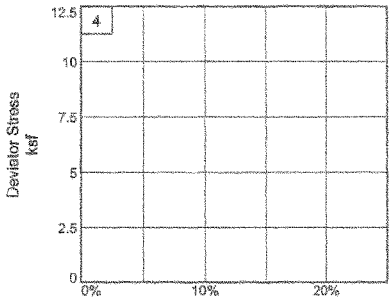
MACTEC ENGINEERING AND CONSULTING, INC.

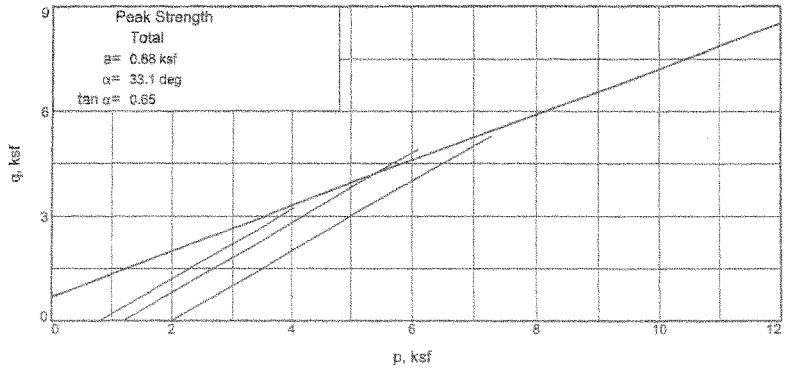
Tested By: mc Checked By: Kajni Sukhwani











Client: Nodarse and Associates
Project: Material Testing-Nodarse
Sample Number: UU-90%-B
Project No.: 6738-05-4573

Reviewed By _____ MACTEC Engineering and Consulting, Inc.

Tested By: mc Checked By: _____

TRIAXIAL COMPRESSION TEST

Unconsolidated Undrained

6/15/2005
10:45 AM

Date:	6-10-05
Client:	Nodarse and Associates
Project:	Material Testing-Nodarse
Project No.:	6738-05-4573
Sample Number:	UU-90%-B
Description:	Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments
Remarks:	
Type of Sample:	remolded
Specific Gravity=2.762	LL= PL= PI=
Test Method:	COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	229.580		1194.700
Moisture content: Dry soil+tare, gms.	204.670		1041.000
Moisture content: Tare, gms.	55.040		115.200
Moisture, %	16.6	22.9	16.6
Moist specimen weight, gms.	1074.0		
Diameter, in.	2.84	2.83	
Area, in.^{2}	6.33	6.28	
Height, in.	5.32	5.29	
Net decrease in height, in.		0.03	
Wet Density, pcf	121.4	129.8	
Dry density, pcf	104.1	105.6	
Void ratio	0.6567	0.6334	
Saturation, %	70.0	100.0	

Test Readings for Specimen No. 1

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm^2
Membrane thickness = 0.02 cm
Cell pressure = 5.60 psi (0.81 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 6.45 ksf at reading no. 18

MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	0.81	0.81	1.00		0.81
1	0.0010	3.00	9.9	0.0	0.23	0.81	1.03	1.28		0.92
2	0.0050	10.00	33.1	0.1	0.76	0.81	1.57	1.94		1.19
3	0.0100	14.00	46.4	0.2	1.06	0.81	1.87	2.32		1.34
4	0.0150	17.00	56.3	0.3	1.29	0.81	2.10	2.60		1.45
5	0.0200	19.00	62.9	0.4	1.44	0.81	2.25	2.78		1.53
6	0.0250	24.00	79.5	0.5	1.82	0.81	2.62	3.25		1.71
7	0.0300	28.00	92.8	0.6	2.12	0.81	2.92	3.62		1.86
8	0.0350	31.00	102.7	0.7	2.34	0.81	3.15	3.90		1.98
9	0.0400	35.00	116.0	0.8	2.64	0.81	3.45	4.27		2.13
10	0.0450	39.00	129.2	0.8	2.94	0.81	3.75	4.65		2.28
11	0.0500	42.00	139.1	0.9	3.16	0.81	3.97	4.92		2.39
12	0.0750	60.00	198.8	1.4	4.50	0.81	5.30	6.58		3.05
13	0.1000	70.00	231.9	1.9	5.22	0.81	6.03	7.47		3.42
14	0.1250	78.00	258.4	2.4	5.79	0.81	6.60	8.18		3.70
15	0.1500	82.00	271.7	2.8	6.06	0.81	6.86	8.51		3.84
16	0.1750	87.00	288.2	3.3	6.40	0.81	7.20	8.93		4.00
17	0.2000	88.00	291.5	3.8	6.44	0.81	7.24	8.98		4.03
18	0.2500	89.00	294.9	4.7	6.45	0.81	7.25	8.99		4.03
19	0.3000	89.00	294.9	5.7	6.38	0.81	7.19	8.92		4.00
20	0.3500	90.00	298.2	6.6	6.39	0.81	7.20	8.92		4.00
21	0.4000	90.00	298.2	7.6	6.33	0.81	7.13	8.84		3.97
22	0.5000	90.00	298.2	9.4	6.20	0.81	7.00	8.68		3.90
23	0.6000	90.00	298.2	11.3	6.07	0.81	6.87	8.52		3.84
24	0.7000	92.00	304.8	13.2	6.07	0.81	6.88	8.53		3.84
25	0.8000	92.00	304.8	15.1	5.94	0.81	6.74	8.36		3.78
26	0.9000	93.00	308.1	17.0	5.87	0.81	6.67	8.28		3.74
27	1.0000	92.00	304.8	18.9	5.67	0.81	6.48	8.04		3.64
28	1.1000	92.00	304.8	20.8	5.54	0.81	6.35	7.87		3.58
29	1.2000	91.00	301.5	22.7	5.35	0.81	6.16	7.63		3.48

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	299.270		1196.700
Moisture content: Dry soil+tare, gms.	265.040		1041.800
Moisture content: Tare, gms.	51.880		106.200
Moisture, %	16.1	23.3	16.6
Moist specimen weight, gms.	1099.1		
Diameter, in.	2.84	2.83	
Area, in.²	6.33	6.28	
Height, in.	5.50	5.47	
Net decrease in height, in.		0.03	
Wet Density, pcf	120.2	129.4	
Dry density, pcf	103.5	105.0	
Void ratio	0.6651	0.6425	
Saturation, %	66.7	100.0	

Test Readings for Specimen No. 2

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Cell pressure = 8.30 psi (1.20 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 9.79 ksf at reading no. 18

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	1.20	1.20	1.00		1.20
1	0.0010	3.00	9.9	0.0	0.23	1.20	1.42	1.19		1.31
2	0.0050	11.00	36.4	0.1	0.84	1.20	2.03	1.70		1.61
3	0.0100	18.00	59.6	0.2	1.37	1.20	2.56	2.14		1.88
4	0.0150	24.00	79.5	0.3	1.82	1.20	3.01	2.52		2.10
5	0.0200	28.00	92.8	0.4	2.12	1.20	3.32	2.77		2.26
6	0.0250	32.00	106.0	0.5	2.42	1.20	3.62	3.03		2.41
7	0.0300	37.00	122.6	0.5	2.80	1.20	3.99	3.34		2.59
8	0.0350	40.00	132.5	0.6	3.02	1.20	4.22	3.53		2.71
9	0.0400	45.00	149.1	0.7	3.40	1.20	4.59	3.84		2.89
10	0.0450	49.00	162.3	0.8	3.69	1.20	4.89	4.09		3.04
11	0.0500	54.00	178.9	0.9	4.07	1.20	5.26	4.40		3.23
12	0.0750	80.00	265.0	1.4	6.00	1.20	7.19	6.02		4.19
13	0.1000	100.00	331.3	1.8	7.46	1.20	8.66	7.24		4.93
14	0.1250	117.00	387.6	2.3	8.69	1.20	9.88	8.27		5.54
15	0.1500	126.00	417.4	2.7	9.31	1.20	10.51	8.79		5.85
16	0.1750	130.00	430.7	3.2	9.56	1.20	10.76	9.00		5.98
17	0.2000	132.00	437.3	3.7	9.67	1.20	10.86	9.09		6.03
18	0.2500	135.00	447.3	4.6	9.79	1.20	10.99	9.19		6.09
19	0.3000	133.00	440.6	5.5	9.55	1.20	10.75	8.99		5.97
20	0.3500	132.00	437.3	6.4	9.39	1.20	10.59	8.86		5.89
21	0.4000	130.00	430.7	7.3	9.16	1.20	10.35	8.66		5.77
22	0.5000	128.00	424.1	9.1	8.84	1.20	10.04	8.40		5.62
23	0.6000	127.00	420.8	11.0	8.59	1.20	9.79	8.19		5.49
24	0.7000	129.00	427.4	12.8	8.55	1.20	9.75	8.15		5.47

MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
25	0.8000	130.00	430.7	14.6	8.44	1.20	9.63	8.06		5.41
26	0.9000	127.00	420.8	16.4	8.07	1.20	9.26	7.75		5.23
27	1.0000	126.00	417.4	18.3	7.83	1.20	9.02	7.55		5.11
28	1.1000	125.00	414.1	20.1	7.59	1.20	8.79	7.35		4.99
29	1.2000	124.00	410.8	21.9	7.36	1.20	8.55	7.16		4.87

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	169.450		1346.000
Moisture content: Dry soil+tare, gms.	152.380		1169.600
Moisture content: Tare, gms.	50.720		115.300
Moisture, %	16.8	22.8	16.7
Moist specimen weight, gms.	1198.4		
Diameter, in.	2.84	2.83	
Area, in.^{2}	6.33	6.29	
Height, in.	5.90	5.88	
Net decrease in height, in.		0.02	
Wet Density, pcf	122.2	129.9	
Dry density, pcf	104.6	105.7	
Void ratio	0.6486	0.6310	
Saturation, %	71.5	100.0	

Test Readings for Specimen No. 3

Load ring constant = 3.313 lbs. per input unit

Membrane modulus = 0.124105 kN/cm^2

Membrane thickness = 0.02 cm

Cell pressure = 13.90 psi (2.00 ksf)

Back pressure = 0.00 psi (0.00 ksf)

Strain rate, in./min. = 0.05

Fail. Stress = 10.56 ksf at reading no. 20

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	2.00	2.00	1.00		2.00
1	0.0010	8.00	26.5	0.0	0.61	2.00	2.61	1.30		2.30
2	0.0050	22.00	72.9	0.1	1.67	2.00	3.67	1.83		2.84
3	0.0100	31.00	102.7	0.2	2.35	2.00	4.35	2.17		3.18
4	0.0150	42.00	139.1	0.3	3.18	2.00	5.18	2.59		3.59
5	0.0200	50.00	165.7	0.3	3.78	2.00	5.78	2.89		3.89
6	0.0250	58.00	192.2	0.4	4.38	2.00	6.38	3.19		4.19
7	0.0300	66.00	218.7	0.5	4.98	2.00	6.98	3.49		4.49
8	0.0350	74.00	245.2	0.6	5.58	2.00	7.58	3.79		4.79
9	0.0400	81.00	268.4	0.7	6.10	2.00	8.10	4.05		5.05
10	0.0450	88.00	291.5	0.8	6.62	2.00	8.63	4.31		5.31
11	0.0500	95.00	314.7	0.9	7.14	2.00	9.15	4.57		5.57
12	0.0750	114.00	377.7	1.3	8.54	2.00	10.54	5.26		6.27
13	0.1000	124.00	410.8	1.7	9.25	2.00	11.25	5.62		6.62
14	0.1250	130.00	430.7	2.1	9.65	2.00	11.65	5.82		6.83
15	0.1500	135.00	447.3	2.6	9.98	2.00	11.98	5.99		6.99

MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
16	0.1750	138.00	457.2	3.0	10.16	2.00	12.16	6.07		7.08
17	0.2000	140.00	463.8	3.4	10.26	2.00	12.26	6.12		7.13
18	0.2500	143.00	473.8	4.3	10.39	2.00	12.39	6.19		7.19
19	0.3000	145.00	480.4	5.1	10.44	2.00	12.44	6.21		7.22
20	0.3500	148.00	490.3	6.0	10.56	2.00	12.56	6.27		7.28
21	0.4000	149.00	493.6	6.8	10.53	2.00	12.53	6.26		7.27
22	0.5000	151.00	500.3	8.5	10.48	2.00	12.48	6.24		7.24
23	0.6000	153.00	506.9	10.2	10.42	2.00	12.42	6.21		7.21
24	0.7000	154.00	510.2	11.9	10.29	2.00	12.29	6.14		7.15
25	0.8000	155.00	513.5	13.6	10.16	2.00	12.16	6.07		7.08
26	0.9000	156.00	516.8	15.3	10.02	2.00	12.02	6.01		7.01
27	1.0000	155.00	513.5	17.0	9.76	2.00	11.76	5.87		6.88
28	1.1000	154.00	510.2	18.7	9.50	2.00	11.50	5.74		6.75
29	1.2000	153.00	506.9	20.4	9.24	2.00	11.24	5.61		6.62

Vaeth, Dick

From: Stathis Payiatakis [stathisp@nodarse.com]
Sent: Monday, February 06, 2006 7:53 AM
To: Vaeth, Dick
Cc: Stathis Payiatakis
Subject: FW: EAA Proctor

Dick,
As agreed on Friday
Regards
Stathis P

From: Coleman, Mark [mailto:MACOLEMAN@mactec.com]
Sent: Friday, February 03, 2006 3:15 PM
To: Stathis Payiatakis
Subject: EAA Proctor

Stathis,

I reviewed the select fill compaction test report for the EAA project, MACTEC project number 6738-05-4573-02. The test specification D-1557-91 procedure B modified shown on the report should be D-698-91 procedure B standard. If you have any questions please call.

Thanks,

Mark Coleman

MACTEC Engineering and Consulting

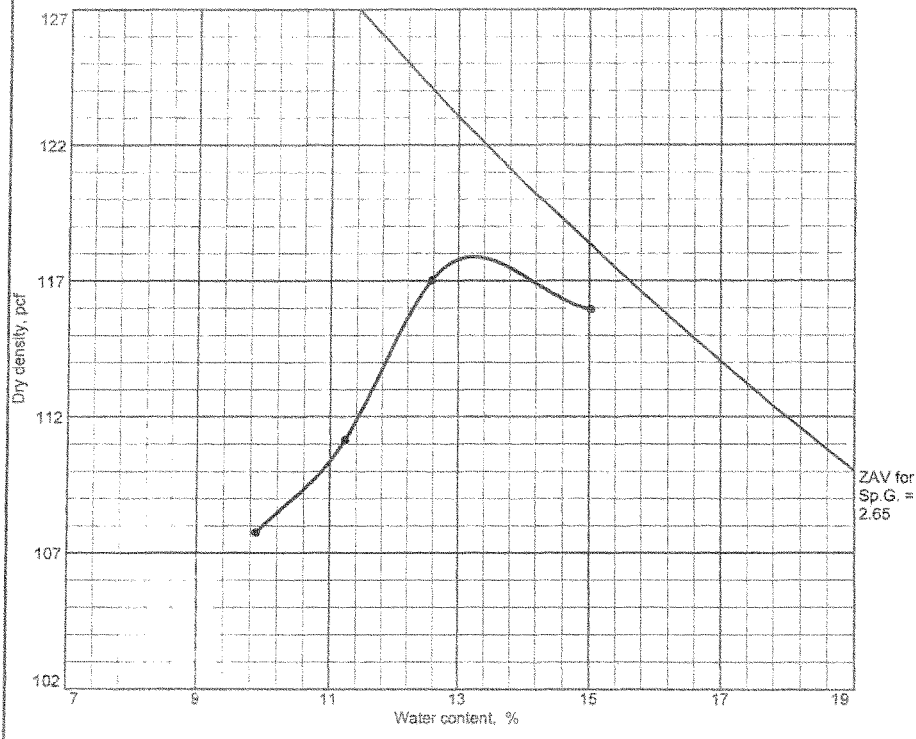
Jacksonville, Florida 32207

904-398-1084

Fax 904-398-1084

macoleman@mactec.com

COMPACTION TEST REPORT

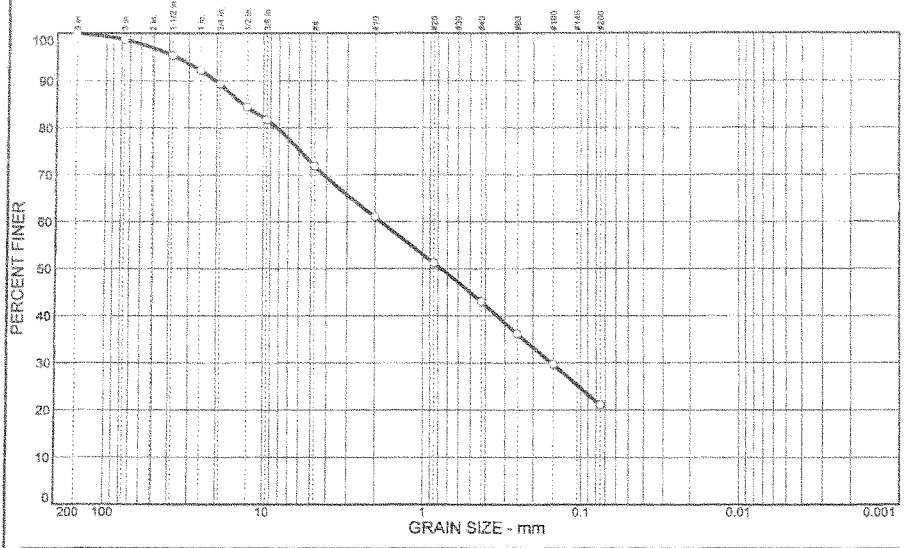


Test specification: ASTM D 1557-91 Procedure B Modified
Oversize correction applied to each point

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in.	% < No.200
	USCS	AASHTO						
	SM	A-1-b					18.3	21.1

ROCK CORRECTED TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 118.0 pcf Optimum moisture = 13.0 %	Light gray and tan clayey fine SAND with limerock and shell fragments
Project No.: 6738-05-4573-02 **Client:** Nodarse and Associates, Inc. **Project:** EAA **Source:** Select Fill **Sample No.:** composite	**Remarks:** Rajni Sukhwani
COMPACTION TEST REPORT MACTEC ENGINEERING AND CONSULTING, INC.	Reviewed By

Grain Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○	1.3	26.8	50.8	21.1		SM	A-1-b		

SIEVE inches size	PERCENT FINER ○
6	100.0
3	98.7
1.5	95.3
1	92.2
.75	89.3
.5	84.4
.375	81.7

GRAIN SIZE	
D_{60}	1.83
D_{30}	0.154
D_{10}	

COEFFICIENTS	
C_c	
C_u	

SIEVE number size	PERCENT FINER ○
#4	71.9
#10	61.0
#20	51.2
#40	43.0
#60	36.2
#100	29.7
#200	21.1

SOIL DESCRIPTION

○ Light gray and tan clayey fine SAND with limerock and shell fragments

REMARKS

○

○ Source: Select Fill Sample No.: composite

MACTEC ENGINEERING. AND CONSULTING, INC.

Client: Nodarse and Associates, Inc.

Project: EAA

Project No.: 6738-05-4573-07

RS

Reviewed By

GRAIN SIZE DISTRIBUTION TEST DATA

Client: Nodarse and Associates, Inc.
Project: EAA
Project Number: 6738-05-4573-02

Sample Data

Source: Select Fill
Sample No.: composite
Elev. or Depth: Sample Length (in./cm.):
Location:
Description: Light gray and tan clayey fine SAND with limerock and shell fragments
Liquid Limit: Plastic Limit:
USCS Classification: SM AASHTO Classification: A-1-b
Testing Remarks:

Mechanical Analysis Data

Initial
Dry sample and tare= 183928.00
Tare = 0.00
Dry sample weight = 183928.00
Sample split on .5 inch sieve
Split sample data:
Sample and tare = 478.20 Tare = .00 Sample weight = 478.20
Cumulative weight retained tare= .00
Tare for cumulative weight retained= .00

Sieve	Cumul. Wt. retained	Percent finer
6 inch	0.00	100.0
3 inch	2404.00	98.7
1.5 inch	8637.00	95.3
1 inch	14330.00	92.2
.75 inch	19677.00	89.3
.5 inch	28701.00	84.4
.375 inch	15.49	81.7
# 4	70.85	71.9
# 10	132.55	61.0
# 20	188.10	51.2
# 40	234.34	43.0
# 60	273.23	36.2
# 100	309.97	29.7
# 200	358.68	21.1

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = 1.3 % GRAVEL = 26.8 % SAND = 50.8
% FINES = 21.1

D_{85}= 13.42 D_{60}= 1.83 D_{50}= 0.77
D_{30}= 0.15

MOISTURE DENSITY TEST DATA

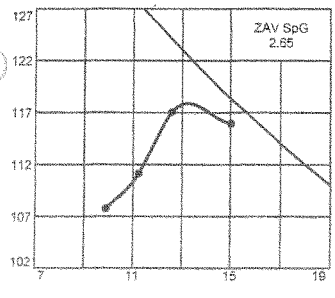
Client: Nodarse and Associates, Inc.
Project: EAA
Project Number: 6738-05-4573-02

Specimen Data

Source: Select Fill
Sample No.: composite
Elev. or Depth: Sample Length (in./cm.):
Location:
Description: Light gray and tan clayey fine SAND with limerock and shell fragments
USCS Classification: SM AASHTO Classification: A-1-b
Natural Moisture: Liquid Limit: Plasticity Index:
Testing Remarks:
Percent retained on 3/8 in. sieve: 18.3
Percent passing No. 200 sieve: 21.1 Specific gravity:

Test Data And Results

Type of test: ASTM D 1557-91 Procedure B Modified
Mold Dia.: 4.00 in. Hammer Wt.: 10 lb. Drop: 18 in.
Layers: five Blows per Layer: 25



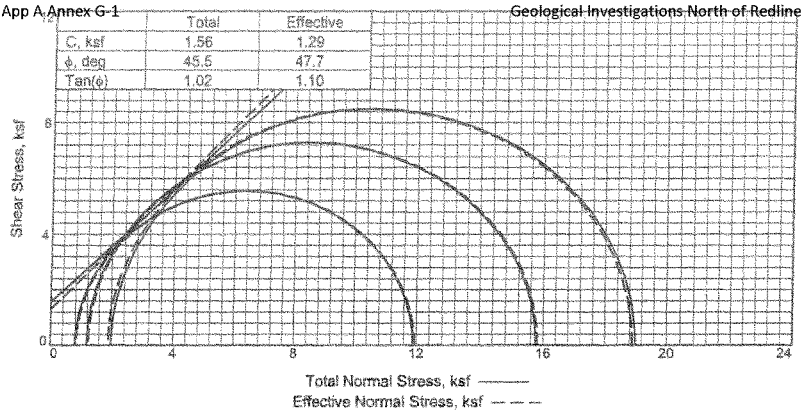
POINT NO.	1	2	3	4
WM + WS	6084.0	6114.0	5941.0	5850.0
WM	4129.0	4129.0	4129.0	4129.0
WW+T	540.90	451.40	507.80	478.20
WD+T	478.20	388.78	455.60	435.46
TARE	0.00	0.00	0.00	0.00
MOIST	13.1	16.1	11.5	9.8
MOISTURE	12.6	15.0	11.2	9.9
DRY DEN	117.0	116.0	111.2	107.8

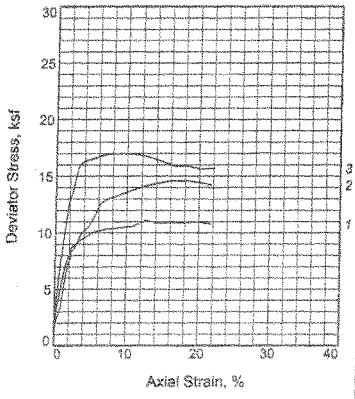
Max dry den= 118.0 pcf Opt moisture= 13.0 %

Uncorrected Results: Max dry den= 115.5 pcf Opt moisture= 14.0 %

ASTM D 4718 Correction Data:
Bulk Specific Gravity of Oversize Material = 2.095
Moisture of Oversize Material = 10.2 %
Corrections Applied to Every Test Point

	Total	Effective
C, ksf	1.56	1.29
ϕ, deg	45.5	47.7
Tan(ϕ)	1.02	1.10





Sample No.		1	2	3
Initial	Water Content,	16.2	16.2	16.2
	Dry Density, pcf	108.3	108.0	110.0
	Saturation,	75.6	75.0	78.7
	Void Ratio	0.5917	0.5966	0.5674
	Diameter, in.	2.84	2.84	2.84
	Height, in.	5.58	5.54	5.43
At Test	Water Content,	20.1	21.1	20.0
	Dry Density, pcf	110.9	108.9	111.1
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.5543	0.5836	0.5518
	Diameter, in.	2.82	2.83	2.83
	Height, in.	5.54	5.53	5.41
Strain rate, in./min.		0.05	0.05	0.05
Back Pressure, ksf		7.2	7.2	7.2
Cell Pressure, ksf		8.0	8.4	9.2
Fail. Stress, ksf		11.1	14.6	17.0
Total Pore Pr., ksf		7.2	7.1	7.3
Ult. Stress, ksf				
Total Pore Pr., ksf				
$\bar{\sigma}_1$ Failure, ksf		11.9	15.8	18.9
$\bar{\sigma}_3$ Failure, ksf		0.8	1.3	1.9

Type of Test: CU with Pore Pressures
Sample Type: remold
Description: Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments

Specific Gravity= 2.762
Remarks:

Reviewed By _____

Client: Nodarse and Associates

Project: Material Testing-Nodarse

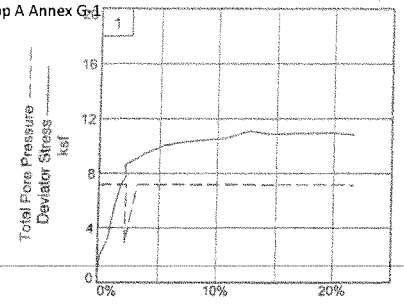
Sample Number: CU-95%-B

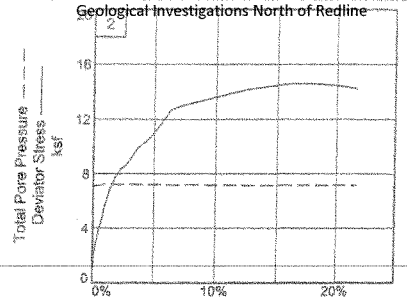
Proj. No.: 6738-05-4575 **Date:** 6-12-05

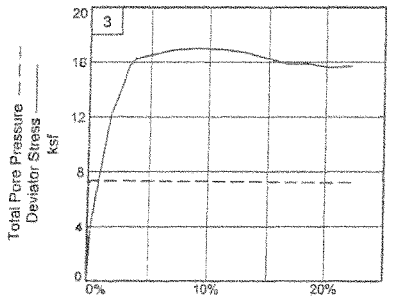
TRIAXIAL SHEAR TEST REPORT

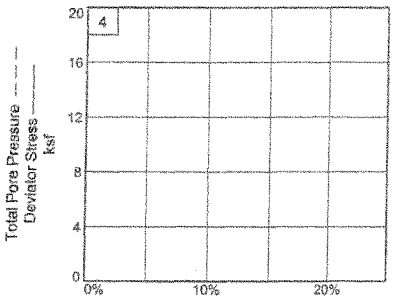
MACTEC ENGINEERING AND CONSULTING, INC.

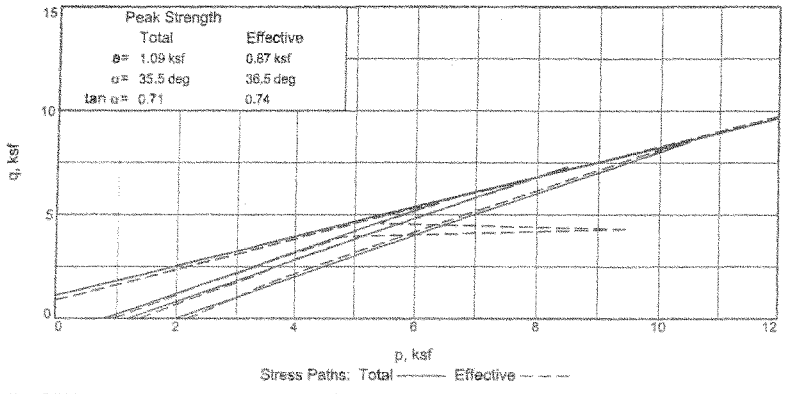
Tested By: mc **Checked By:** Rajni Sukhwani











Client: Nodarse and Associates
Project: Material Testing-Nodarse
Sample Number: CU-95%-B
Project No.: 6738-05-4573

Reviewed By _____ MACTEC Engineering and Consulting, Inc.

Tested By: mc _____ **Checked By:** _____

TRIAXIAL COMPRESSION TEST 6/16/2005
CU with Pore Pressures 10:57 AM

Date: 6-12-05
Client: Nodarse and Associates
Project: Material Testing-Nodarse
Project No.: 6738-05-4573
Sample Number: CU-95%-B
Description: Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments
Remarks:
Type of Sample: remold
Specific Gravity=2.762 LL= PL= PI=
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	173.410			1326.000
Moisture content: Dry soil+tare, gms.	156.910			1142.000
Moisture content: Tare, gms.	55.030			115.790
Moisture, %	16.2	21.4	20.1	17.9
Moist specimen weight, gms.	1167.9			
Diameter, in.	2.84	2.84	2.82	
Area, in.²	6.33	6.33	6.23	
Height, in.	5.58	5.58	5.54	
Net decrease in height, in.		0.00	0.04	
Wet Density, pcf	125.9	131.5	133.2	
Dry density, pcf	108.3	108.3	110.9	
Void ratio	0.5917	0.5917	0.5543	
Saturation, %	75.6	100.0	100.0	

Test Readings for Specimen No. 1

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Consolidation cell pressure = 55.60 psi (8.01 ksf)
Consolidation back pressure = 50.00 psi (7.20 ksf)
Consolidation effective confining stress = 0.81 ksf
Strain rate, in./min. = 0.05
Fail. Stress = 11.10 ksf at reading no. 24

MACTEC Engineering and Consulting, Inc.

App A Annex G-1 Test Readings for Specimen Geological Investigations North of Redline

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	0.95	0.95	1.00	49.00	0.95	0.00
1	0.0010	8.00	26.5	0.0	0.61	0.94	1.55	1.65	49.10	1.24	0.31
2	0.0050	19.00	62.9	0.1	1.45	0.91	2.36	2.60	49.30	1.63	0.73
3	0.0100	26.00	86.1	0.2	1.99	0.89	2.88	3.22	49.40	1.89	0.99
4	0.0150	29.00	96.1	0.3	2.21	0.88	3.09	3.52	49.50	1.98	1.11
5	0.0200	31.00	102.7	0.4	2.36	0.86	3.23	3.74	49.60	2.05	1.18
6	0.0250	34.00	112.6	0.5	2.59	0.84	3.43	4.10	49.80	2.13	1.29
7	0.0300	36.00	119.3	0.5	2.74	0.84	3.57	4.28	49.80	2.21	1.37
8	0.0350	38.00	125.9	0.6	2.89	0.82	3.71	4.52	49.90	2.27	1.44
9	0.0400	40.00	132.5	0.7	3.04	0.82	3.86	4.70	49.90	2.34	1.52
10	0.0450	43.00	142.5	0.8	3.26	0.82	4.08	4.98	49.90	2.45	1.63
11	0.0500	46.00	152.4	0.9	3.49	0.84	4.32	5.18	49.80	2.58	1.74
12	0.0750	75.00	248.5	1.4	5.66	0.85	6.51	7.66	49.70	3.68	2.83
13	0.1000	95.00	314.7	1.8	7.14	0.88	8.02	9.13	49.50	4.45	3.57
14	0.1250	105.00	347.9	2.3	7.85	0.86	8.72	10.09	49.60	4.79	3.93
15	0.1200	115.00	381.0	2.2	8.61	5.20	13.81	2.66	~~19.50~~	9.50	4.30
16	0.1750	123.00	407.5	3.2	9.11	0.88	9.99	11.38	49.50	5.44	4.56
17	0.2000	127.00	420.8	3.6	9.37	0.84	10.20	12.21	49.80	5.52	4.68
18	~~0.3000~~	139.00	460.5	5.4	10.06	0.84	10.89	13.04	49.80	5.86	5.03
19	0.3000	139.00	460.5	5.4	10.06	0.84	10.89	13.04	49.80	5.86	5.03
20	0.3500	142.00	470.4	6.3	10.18	0.84	11.01	13.19	49.80	5.92	5.09
21	0.4000	145.00	480.4	7.2	10.29	0.85	11.14	13.12	49.70	6.00	5.15
22	0.5000	150.00	497.0	9.0	10.44	0.85	11.29	13.29	49.70	6.07	5.22
23	0.6000	155.00	513.5	10.8	10.57	0.85	11.42	13.45	49.70	6.14	5.29
24	0.7000	166.00	550.0	12.6	11.10	0.85	11.95	14.06	49.70	6.40	5.55
25	0.8000	166.00	550.0	14.5	10.87	0.86	11.73	13.58	49.60	6.30	5.43
26	0.9000	170.00	563.2	16.3	10.89	0.86	11.76	13.61	49.60	6.31	5.45
27	1.0000	174.00	576.5	18.1	10.91	0.86	11.77	13.63	49.60	6.32	5.45
28	1.1000	179.00	593.0	19.9	10.98	0.88	11.85	13.49	49.50	6.37	5.49
29	1.2000	180.00	596.3	21.7	10.79	0.89	11.68	13.08	49.40	6.29	5.39

Correction Made MM 6-16-05

MACTEC Engineering and Consulting, Inc.

App A Annex G-1 — Parameters for Specimen Geological Investigations North of Redline

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	173.410			1288.400
Moisture content: Dry soil+tare, gms.	156.910			1108.100
Moisture content: Tare, gms.	55.030			95.600
Moisture, %	16.2	21.6	21.1	17.8
Moist specimen weight, gms.	1156.0			
Diameter, in.	2.84	2.84	2.83	
Area, in.²	6.33	6.33	6.30	
Height, in.	5.54	5.54	5.53	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	125.5	131.3	131.9	
Dry density, pcf	108.0	108.0	108.9	
Void ratio	0.5966	0.5966	0.5836	
Saturation, %	75.0	100.0	100.0	

Test Readings for Specimen No. 2

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Consolidation cell pressure = 58.30 psi (8.40 ksf)
Consolidation back pressure = 50.00 psi (7.20 ksf)
Consolidation effective confining stress = 1.20 ksf
Strain rate, in./min. = 0.05
Fail. Stress = 14.58 ksf at reading no. 26

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	1.38	1.38	1.00	48.70	1.38	0.00
1	0.0010	10.00	33.1	0.0	0.76	1.35	2.11	1.56	48.90	1.73	0.38
2	0.0050	24.00	79.5	0.1	1.82	1.31	3.13	2.39	49.20	2.22	0.91
3	0.0100	33.00	109.3	0.2	2.49	1.30	3.79	2.92	49.30	2.54	1.25
4	0.0150	39.00	129.2	0.3	2.95	1.28	4.23	3.30	49.40	2.75	1.47
5	0.0200	44.00	145.8	0.4	3.32	1.28	4.60	3.59	49.40	2.94	1.66
6	0.0250	49.00	162.3	0.5	3.69	1.27	4.96	3.91	49.50	3.11	1.85
7	0.0300	53.00	175.6	0.5	3.99	1.27	5.26	4.15	49.50	3.26	2.00
8	0.0350	57.00	188.8	0.6	4.29	1.25	5.54	4.42	49.60	3.40	2.14
9	0.0400	62.00	205.4	0.7	4.66	1.22	5.88	4.81	49.80	3.55	2.33
10	0.0450	66.00	218.7	0.8	4.96	1.20	6.15	5.15	50.00	3.67	2.48
11	0.0500	72.00	238.5	0.9	5.40	1.17	6.57	5.63	50.20	3.87	2.70
12	0.0750	91.00	301.5	1.4	6.80	1.17	7.96	6.83	50.20	4.56	3.40
13	0.1000	104.00	344.6	1.8	7.73	1.20	8.93	7.47	50.00	5.06	3.87
14	0.1250	112.00	371.1	2.3	8.29	1.20	9.48	7.94	50.00	5.34	4.14
15	0.1500	117.00	387.6	2.7	8.62	1.20	9.81	8.21	50.00	5.50	4.31
16	0.1750	125.00	414.1	3.2	9.17	1.20	10.36	8.67	50.00	5.78	4.58
17	0.2000	135.00	447.3	3.6	9.85	1.21	11.06	9.15	49.90	6.14	4.93
18	0.2500	145.00	480.4	4.5	10.48	1.21	11.69	9.67	49.90	6.45	5.24
19	0.3000	160.00	530.1	5.4	11.46	1.21	12.67	10.47	49.90	6.94	5.73
20	0.3500	178.00	589.7	6.3	12.62	1.22	13.85	11.31	49.80	7.54	6.31
21	0.4000	184.00	609.6	7.2	12.92	1.22	14.15	11.56	49.80	7.69	6.46
22	0.5000	194.00	642.7	9.0	13.36	1.24	14.60	11.79	49.70	7.92	6.68
23	0.6000	204.00	675.9	10.9	13.77	1.25	15.02	11.99	49.60	8.14	6.88

MACTEC Engineering and Consulting, Inc.

App A Annex G-1 — Test Readings for Specimen — Geological Investigations North of Redline

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
24	0.7000	214.00	709.0	12.7	14.15	1.27	15.42	12.17	49.50	8.34	7.08
25	0.8000	222.00	735.5	14.5	14.38	1.27	15.64	12.34	49.50	8.46	7.19
26	0.9000	230.00	762.0	16.3	14.58	1.25	15.83	12.64	49.60	8.54	7.29
27	1.0000	235.00	778.6	18.1	14.57	1.25	15.83	12.63	49.60	8.54	7.29
28	1.1000	238.00	788.5	19.9	14.43	1.25	15.69	12.52	49.60	8.47	7.22
29	1.2000	240.00	795.1	21.7	14.23	1.25	15.48	12.36	49.60	8.37	7.11

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	132.350			1281.400
Moisture content: Dry soil+tare, gms.	121.490			1110.500
Moisture content: Tare, gms.	54.280			106.100
Moisture, %	16.2	20.5	20.0	17.0
Moist specimen weight, gms.	1153.8			
Diameter, in.	2.84	2.84	2.83	
Area, in.²	6.33	6.33	6.29	
Height, in.	5.43	5.43	5.41	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	127.8	132.6	133.3	
Dry density, pcf	110.0	110.0	111.1	
Void ratio	0.5674	0.5674	0.5518	
Saturation, %	78.7	100.0	100.0	

Test Readings for Specimen No. 3

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Consolidation cell pressure = 63.90 psi (9.20 ksf)
Consolidation back pressure = 50.00 psi (7.20 ksf)
Consolidation effective confining stress = 2.00 ksf
Strain rate, in./min. = 0.05
Fail. Stress = 17.00 ksf at reading no. 22

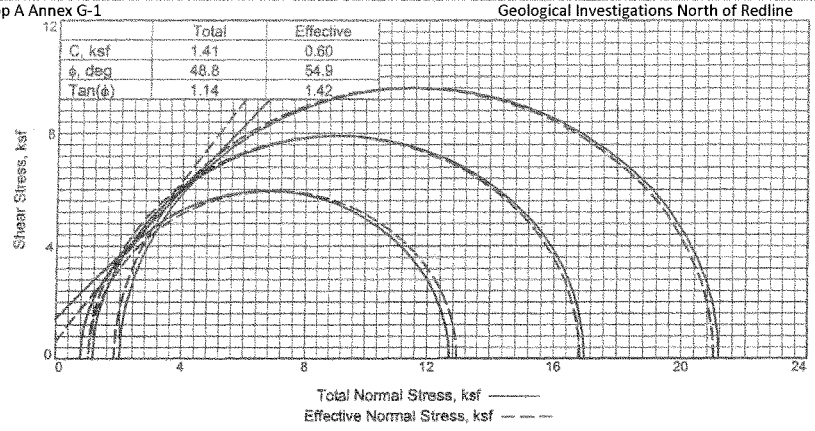
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	2.17	2.17	1.00	48.80	2.17	0.00
1	0.0010	5.00	16.6	0.0	0.38	2.17	2.55	1.17	48.80	2.36	0.19
2	0.0050	22.00	72.9	0.1	1.67	2.03	3.70	1.82	49.80	2.86	0.83
3	0.0100	39.00	129.2	0.2	2.95	1.90	4.85	2.55	50.70	3.38	1.48
4	0.0150	52.00	172.3	0.3	3.93	1.86	5.79	3.12	51.00	3.82	1.97
5	0.0200	62.00	205.4	0.4	4.68	1.84	6.53	3.54	51.10	4.18	2.34
6	0.0250	69.00	228.6	0.5	5.21	1.84	7.05	3.82	51.10	4.45	2.60
7	0.0300	77.00	255.1	0.6	5.81	1.84	7.65	4.15	51.10	4.75	2.90
8	0.0350	85.00	281.6	0.6	6.40	1.84	8.25	4.47	51.10	5.04	3.20
9	0.0400	91.00	301.5	0.7	6.85	1.84	8.69	4.72	51.10	5.27	3.42
10	0.0450	98.00	324.7	0.8	7.37	1.84	9.21	5.00	51.10	5.53	3.68
11	0.0500	104.00	344.6	0.9	7.81	1.84	9.65	5.24	51.10	5.75	3.91
12	0.0750	138.00	457.2	1.4	10.32	1.86	12.17	6.55	51.00	7.02	5.16
13	0.1000	166.00	550.0	1.8	12.35	1.86	14.21	7.65	51.00	8.03	6.18

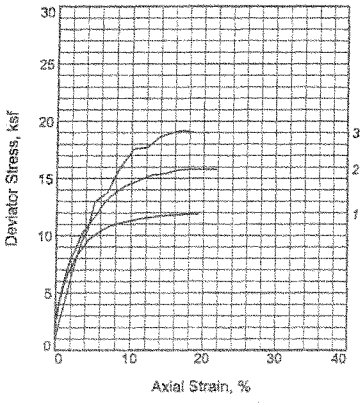
MACTEC Engineering and Consulting, Inc.

App A Annex G-1 Test Readings for Specimen Geological Investigations North of Redline

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
14	0.1250	180.00	596.3	2.3	13.33	1.86	15.19	8.18	51.00	8.52	6.67
15	0.1500	198.00	656.0	2.8	14.60	1.87	16.47	8.80	50.90	9.17	7.30
16	0.1750	215.00	712.3	3.2	15.77	1.87	17.64	9.43	50.90	9.76	7.89
17	0.2000	222.00	735.5	3.7	16.21	1.87	18.08	9.66	50.90	9.98	8.10
18	0.2500	227.00	752.1	4.6	16.41	1.87	18.29	9.77	50.90	10.08	8.21
19	0.3000	232.00	768.6	5.5	16.61	1.87	18.49	9.87	50.90	10.18	8.31
20	0.3500	237.00	785.2	6.5	16.81	1.87	18.68	9.98	50.90	10.27	8.40
21	0.4000	241.00	798.4	7.4	16.92	1.89	18.81	9.97	50.80	10.35	8.46
22	0.5000	247.00	818.3	9.2	17.00	1.90	18.90	9.94	50.70	10.40	8.50
23	0.6000	251.00	831.6	11.1	16.92	1.92	18.83	9.83	50.60	10.37	8.46
24	0.7000	253.00	838.2	12.9	16.70	1.93	18.63	9.65	50.50	10.28	8.35
25	0.8000	252.00	834.9	14.8	16.28	1.94	18.22	9.37	50.40	10.08	8.14
26	0.9000	251.00	831.6	16.6	15.86	1.96	17.82	9.10	50.30	9.89	7.93
27	1.0000	257.00	851.4	18.5	15.88	1.97	17.86	9.05	50.20	9.91	7.94
28	1.1000	258.00	854.8	20.3	15.58	1.99	17.57	8.84	50.10	9.78	7.79
29	1.2000	266.00	881.3	22.2	15.69	2.00	17.70	8.84	50.00	9.85	7.85

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Sample No.		1	2	3
Initial	Water Content,	16.6	16.6	16.6
	Dry Density, pcf	109.1	109.5	109.5
	Saturation,	79.1	79.9	79.8
	Void Ratio	0.5800	0.5745	0.5747
	Diameter, in.	2.84	2.84	2.84
	Height, in.	5.70	5.52	5.82
At Test	Water Content,	20.7	20.0	20.3
	Dry Density, pcf	109.8	111.1	110.5
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.5709	0.5523	0.5609
	Diameter, in.	2.83	2.83	2.83
	Height, in.	5.69	5.49	5.80
Strain rate, in./min.		0.05	0.05	0.05
Back Pressure, ksf		7.2	7.2	7.2
Cell Pressure, ksf		8.0	8.4	9.2
Fail. Stress, ksf		11.9	15.8	19.2
Total Pore Pr., ksf		7.0	7.3	7.4
Ult. Stress, ksf				
Total Pore Pr., ksf				
$\bar{\sigma}_1$ Failure, ksf		12.9	16.9	21.0
$\bar{\sigma}_3$ Failure, ksf		1.1	1.1	1.8

Type of Test: CU with Pore Pressures
Sample Type: remolded
Description: Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments

Specific Gravity= 2.762
Remarks:

Reviewed By _____

Client: Nodarse and Associates

Project: Material Testing-Nodarse

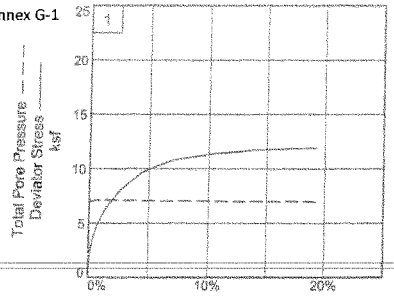
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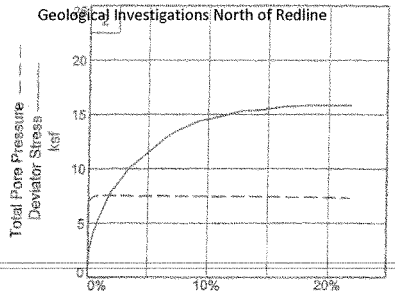
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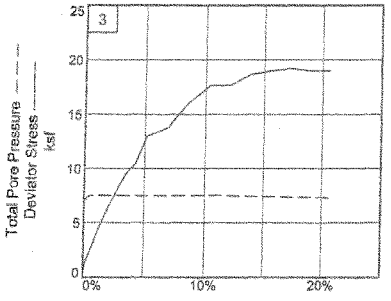
TRIAXIAL SHEAR TEST REPORT

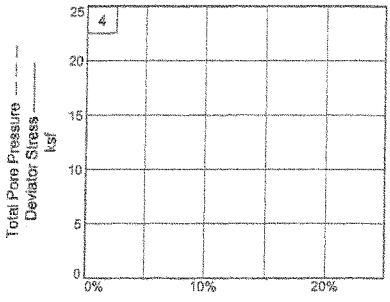
MACTEC ENGINEERING AND CONSULTING, INC.

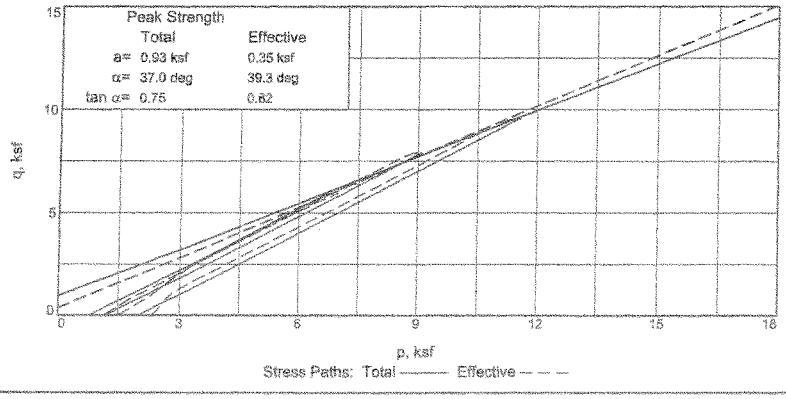
Tested By: mc **Checked By:** Rajni Sukhwani











Client: Nodarse and Associates
Project: Material Testing-Nodarse
Sample Number: CU-95%-A
Project No.: 6738-05-4573

Reviewed By _____ MACTEC Engineering and Consulting, Inc.

Tested By: mc _____ **Checked By:** _____

TRIAXIAL COMPRESSION TEST 6/16/2005
CU with Pore Pressures 10:39 AM

Date:	6-10-05
Client:	Nodarse and Associates
Project:	Material Testing-Nodarse
Project No.:	6738-05-4573
Sample Number:	CU-95%-A
Description:	Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments
Remarks:	
Type of Sample:	remolded
Specific Gravity=2.762	LL= PL= PI=
Test Method:	COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	188.090			1333.800
Moisture content: Dry soil+tare, gms.	168.510			1149.300
Moisture content: Tare, gms.	50.650			95.400
Moisture, %	16.6	21.0	20.7	17.5
Moist specimen weight, gms.	1206.2			
Diameter, in.	2.84	2.84	2.83	
Area, in.²	6.33	6.33	6.31	
Height, in.	5.70	5.70	5.69	
Net decrease in height, in.		0.00	0.01	
Wet Density, pcf	127.3	132.0	132.5	
Dry density, pcf	109.1	109.1	109.8	
Void ratio	0.5800	0.5800	0.5709	
Saturation, %	79.1	100.0	100.0	

Test Readings for Specimen No. 1

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Consolidation cell pressure = 55.60 psi (8.01 ksf)
Consolidation back pressure = 50.00 psi (7.20 ksf)
Consolidation effective confining stress = 0.81 ksf
Strain rate, in./min. = 0.05
Fail. Stress = 11.89 ksf at reading no. 28

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Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	1.17	1.17	1.00	47.50	1.17	0.00
1	0.0010	5.00	16.6	0.0	0.38	1.11	1.49	1.34	47.90	1.30	0.19
2	0.0050	22.00	72.9	0.1	1.66	1.01	2.67	2.65	48.60	1.84	0.83
3	0.0100	35.00	116.0	0.2	2.64	0.99	3.64	3.66	48.70	2.31	1.32
4	0.0150	41.00	135.8	0.3	3.09	1.01	4.10	4.07	48.60	2.55	1.55
5	0.0200	47.00	155.7	0.4	3.54	0.96	4.51	4.67	48.90	2.74	1.77
6	0.0250	51.00	169.0	0.4	3.84	0.96	4.80	4.98	48.90	2.88	1.92
7	0.0300	55.00	182.2	0.5	4.14	0.94	5.07	5.42	49.10	3.00	2.07
8	0.0350	59.00	195.5	0.6	4.43	0.92	5.35	5.81	49.20	3.14	2.22
9	0.0400	63.00	208.7	0.7	4.73	0.91	5.64	6.21	49.30	3.27	2.36
10	0.0450	66.00	218.7	0.8	4.95	0.91	5.86	6.46	49.30	3.38	2.48
11	0.0500	69.00	228.6	0.9	5.17	0.89	6.06	6.79	49.40	3.48	2.59
12	0.0750	82.00	271.7	1.3	6.12	0.89	7.01	7.85	49.40	3.95	3.06
13	0.1000	92.00	304.8	1.8	6.83	0.91	7.74	8.53	49.30	4.32	3.42
14	0.1250	100.00	331.3	2.2	7.39	0.91	8.30	9.15	49.30	4.60	3.70
15	0.1500	109.00	361.1	2.6	8.02	0.92	8.95	9.71	49.20	4.93	4.01
16	0.1750	115.00	381.0	3.1	8.43	0.92	9.35	10.14	49.20	5.14	4.21
17	0.2000	121.00	400.9	3.5	8.83	0.92	9.75	10.58	49.20	5.33	4.41
18	0.2500	133.00	440.6	4.4	9.61	0.94	10.55	11.27	49.10	5.74	4.81
19	0.3000	140.00	463.8	5.3	10.03	0.94	10.96	11.71	49.10	5.95	5.01
20	0.3500	147.00	487.0	6.2	10.43	0.95	11.38	11.97	49.00	6.17	5.21
21	0.4000	153.00	506.9	7.0	10.75	0.96	11.72	12.15	48.90	6.34	5.38
22	0.5000	161.00	533.4	8.8	11.10	0.96	12.07	12.51	48.90	6.52	5.55
23	0.6000	168.00	556.6	10.5	11.36	0.99	12.36	12.43	48.70	6.67	5.68
24	0.7000	174.00	576.5	12.3	11.54	1.01	12.54	12.44	48.60	6.78	5.77
25	0.8000	180.00	596.3	14.1	11.69	1.02	12.72	12.44	48.50	6.87	5.85
26	0.9000	185.00	612.9	15.8	11.77	1.04	12.81	12.36	48.40	6.92	5.89
27	1.0000	190.00	629.5	17.6	11.84	1.04	12.88	12.42	48.40	6.96	5.92
28	1.1000	195.00	646.0	19.3	11.89	1.05	12.94	12.31	48.30	7.00	5.95

App A Annex G-1 — Geological Investigations North of Redline

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	188.090			1272.600
Moisture content: Dry soil+tare, gms.	168.510			1089.700
Moisture content: Tare, gms.	50.650			106.200
Moisture, %	16.6	20.8	20.0	18.6
Moist specimen weight, gms.	1172.2			
Diameter, in.	2.84	2.84	2.83	
Area, in.^{2}	6.33	6.33	6.28	
Height, in.	5.52	5.52	5.49	
Net decrease in height, in.		0.00	0.03	
Wet Density, pcf	127.7	132.3	133.3	
Dry density, pcf	109.5	109.5	111.1	
Void ratio	0.5745	0.5745	0.5523	
Saturation, %	79.9	100.0	100.0	

Test Readings for Specimen No. 2

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm^2
Membrane thickness = 0.02 cm
Consolidation cell pressure = 58.30 psi (8.40 ksf)
Consolidation back pressure = 50.00 psi (7.20 ksf)
Consolidation effective confining stress = 1.20 ksf
Strain rate, in./min. = 0.05
Fail. Stress = 15.81 ksf at reading no. 28

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	1.51	1.51	1.00	47.80	1.51	0.00
1	0.0010	10.00	33.1	0.0	0.76	1.47	2.23	1.52	48.10	1.85	0.38
2	0.0050	29.00	96.1	0.1	2.20	1.31	3.51	2.68	49.20	2.41	1.10
3	0.0100	39.00	129.2	0.2	2.96	1.17	4.13	3.54	50.20	2.65	1.48
4	0.0150	45.00	149.1	0.3	3.41	1.08	4.49	4.16	50.80	2.79	1.71
5	0.0200	50.00	165.7	0.4	3.79	1.02	4.81	4.70	51.20	2.92	1.89
6	0.0250	55.00	182.2	0.5	4.16	0.96	5.13	5.31	51.60	3.05	2.08
7	0.0300	59.00	195.5	0.5	4.46	0.94	5.40	5.77	51.80	3.17	2.23
8	0.0350	62.00	205.4	0.6	4.68	0.91	5.59	6.16	52.00	3.25	2.34
9	0.0400	66.00	218.7	0.7	4.98	0.89	5.87	6.58	52.10	3.38	2.49
10	0.0450	70.00	231.9	0.8	5.28	0.88	6.16	7.01	52.20	3.52	2.64
11	0.0500	73.00	241.8	0.9	5.50	0.88	6.38	7.26	52.20	3.63	2.75
12	0.0750	88.00	291.5	1.4	6.60	0.88	7.48	8.51	52.20	4.18	3.30
13	0.1000	103.00	341.2	1.8	7.69	0.88	8.57	9.75	52.20	4.72	3.84
14	0.1250	112.00	371.1	2.3	8.32	0.88	9.20	10.47	52.20	5.04	4.16
15	0.1500	121.00	400.9	2.7	8.95	0.88	9.83	11.19	52.20	5.35	4.47
16	0.1750	132.00	437.3	3.2	9.72	0.89	10.61	11.88	52.10	5.75	4.86
17	0.2000	140.00	463.8	3.6	10.26	0.91	11.16	12.31	52.00	6.04	5.13
18	0.2500	152.00	503.6	4.6	11.03	0.91	11.94	13.16	52.00	6.42	5.52
19	0.3000	165.00	546.6	5.5	11.86	0.89	12.75	14.28	52.10	6.82	5.93
20	0.3500	179.00	593.0	6.4	12.74	0.91	13.65	15.05	52.00	7.28	6.37
21	0.4000	190.00	629.5	7.3	13.39	0.92	14.32	15.53	51.90	7.62	6.70
22	0.5000	207.00	685.8	9.1	14.31	0.92	15.23	16.52	51.90	8.07	7.15
23	0.6000	218.00	722.2	10.9	14.76	0.94	15.70	16.77	51.80	8.32	7.38

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Test Readings for Specimen

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
24	0.7000	230.00	762.0	12.7	15.26	0.95	16.21	17.05	51.70	8.58	7.63
25	0.8000	237.00	785.2	14.6	15.39	0.96	16.36	16.96	51.60	8.66	7.70
26	0.9000	247.00	818.3	16.4	15.70	0.99	16.70	16.80	51.40	8.84	7.85
27	1.0000	254.00	841.5	18.2	15.80	1.02	16.82	16.45	51.20	8.92	7.90
28	1.1000	260.00	861.4	20.0	15.81	1.05	16.86	16.04	51.00	8.96	7.90
29	1.2000	266.00	881.3	21.8	15.81	1.12	16.93	15.07	50.50	9.03	7.90

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	216.390			1358.600
Moisture content: Dry soil+tare, gms.	192.800			1164.300
Moisture content: Tare, gms.	50.680			108.400
Moisture, %	16.6	20.8	20.3	18.4
Moist specimen weight, gms.	1235.6			
Diameter, in.	2.84	2.84	2.83	
Area, in.^{2}	6.33	6.33	6.30	
Height, in.	5.82	5.82	5.80	
Net decrease in height, in.		0.00	0.02	
Wet Density, pcf	127.7	132.3	132.9	
Dry density, pcf	109.5	109.5	110.5	
Void ratio	0.5747	0.5747	0.5609	
Saturation, %	79.8	100.0	100.0	

Test Readings for Specimen No. 3

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm^2
Membrane thickness = 0.02 cm
Consolidation cell pressure = 63.90 psi (9.20 ksf)
Consolidation back pressure = 50.00 psi (7.20 ksf)
Consolidation effective confining stress = 2.00 ksf
Strain rate, in./min. = 0.05
Fail. Stress = 19.19 ksf at reading no. 26

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	2.30	2.30	1.00	47.90	2.30	0.00
1	0.0010	4.00	13.3	0.0	0.30	2.28	2.58	1.13	48.10	2.43	0.15
2	0.0050	11.00	36.4	0.1	0.83	2.12	2.95	1.39	49.20	2.53	0.42
3	0.0100	18.00	59.6	0.2	1.36	1.97	3.33	1.69	50.20	2.65	0.68
4	0.0150	21.00	69.6	0.3	1.59	1.89	3.47	1.84	50.80	2.68	0.79
5	0.0200	24.00	79.5	0.3	1.81	1.83	3.64	1.99	51.20	2.73	0.91
6	0.0250	28.00	92.8	0.4	2.11	1.77	3.88	2.19	51.60	2.83	1.06
7	0.0300	31.00	102.7	0.5	2.34	1.74	4.08	2.34	51.80	2.91	1.17
8	0.0350	35.00	116.0	0.6	2.64	1.71	4.35	2.54	52.00	3.03	1.32
9	0.0400	38.00	125.9	0.7	2.86	1.70	4.56	2.68	52.10	3.13	1.43
10	0.0450	41.00	135.8	0.8	3.08	1.68	4.77	2.83	52.20	3.23	1.54
11	0.0500	44.00	145.8	0.9	3.30	1.68	4.99	2.96	52.20	3.34	1.65
12	0.0750	60.00	198.8	1.3	4.49	1.68	6.17	3.66	52.20	3.93	2.24
13	0.1000	75.00	248.5	1.7	5.58	1.68	7.27	4.31	52.20	4.48	2.79

App A Annex G-1 Geological Investigations North of Redline

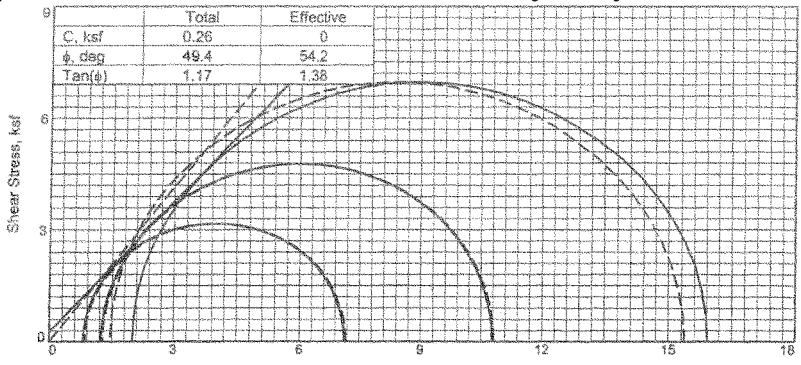
Test Readings for Specimen No. 3

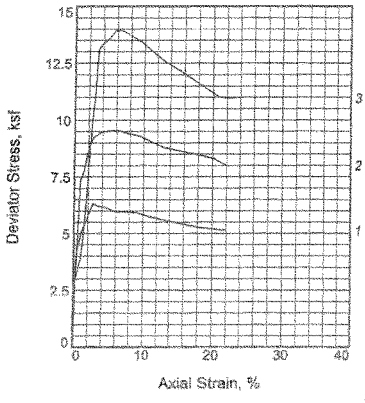
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
14	0.1250	89.00	294.9	2.2	6.60	1.68	8.28	4.92	52.20	4.98	3.30
15	0.1500	102.00	337.9	2.6	7.53	1.68	9.21	5.47	52.20	5.45	3.76
16	0.1750	116.00	384.3	3.0	8.52	1.70	10.22	6.02	52.10	5.96	4.26
17	0.2000	129.00	427.4	3.4	9.44	1.71	11.15	6.51	52.00	6.43	4.72
18	0.2500	145.00	480.4	4.3	10.51	1.71	12.22	7.13	52.00	6.97	5.26
19	0.3000	180.00	596.3	5.2	12.93	1.73	14.66	8.48	51.90	8.19	6.47
20	0.4000	195.00	646.0	6.9	13.75	1.73	15.48	8.96	51.90	8.60	6.88
21	0.5000	232.00	768.6	8.6	16.06	1.71	17.77	10.37	52.00	9.74	8.03
22	0.6000	259.00	858.1	10.3	17.59	1.68	19.28	11.44	52.20	10.48	8.80
23	0.7000	265.00	877.9	12.1	17.65	1.73	19.38	11.22	51.90	10.55	8.83
24	0.8000	285.00	944.2	13.8	18.61	1.77	20.38	11.51	51.60	11.08	9.31
25	0.9000	296.00	980.6	15.5	18.95	1.80	20.75	11.53	51.40	11.27	9.47
26	1.0000	306.00	1013.8	17.2	19.19	1.83	21.01	11.49	51.20	11.42	9.59
27	1.1000	309.00	1023.7	19.0	18.97	1.86	20.83	11.21	51.00	11.34	9.49
28	1.2000	316.00	1046.9	20.7	18.99	1.93	20.92	10.84	50.50	11.42	9.49

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App A Annex G-1 Geological Investigations North of Redline

	Total	Effective
C, ksf	0.26	0
ϕ, deg	49.4	54.2
Tan(ϕ)	1.17	1.38





Sample No.		1	2	3
Initial	Water Content,	16.2	16.2	16.2
	Dry Density, pcf	103.7	104.0	103.8
	Saturation,	67.5	67.9	67.7
	Void Ratio	0.6631	0.6587	0.6612
	Diameter, in.	2.84	2.84	2.84
	Height, in.	5.50	5.50	5.29
At Test	Water Content,	22.5	22.4	22.1
	Dry Density, pcf	106.3	106.5	107.1
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.6225	0.6191	0.6107
	Diameter, in.	2.82	2.82	2.81
	Height, in.	5.46	5.46	5.24
Strain rate, in./min.		0.05	0.05	0.05
Back Pressure, ksf		7.2	7.2	7.2
Cell Pressure, ksf		8.0	8.4	9.2
Fail. Stress, ksf		6.3	9.5	13.9
Total Pore Pr., ksf		7.2	7.2	7.7
Ult. Stress, ksf				
Total Pore Pr., ksf				
$\bar{\sigma}_1$ Failure, ksf		7.2	10.8	15.4
$\bar{\sigma}_3$ Failure, ksf		0.8	1.3	1.5

Type of Test: CU with Pore Pressures
Sample Type: remold
Description: Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments

Specific Gravity= 2.762
Remarks:

Reviewed By _____

Client: Nodarse and Associates

Project: Material Testing-Nodarse

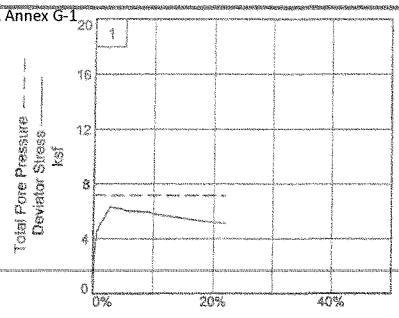
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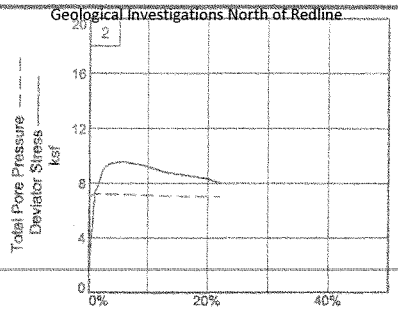
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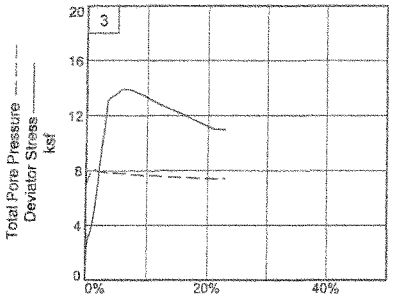
TRIAXIAL SHEAR TEST REPORT

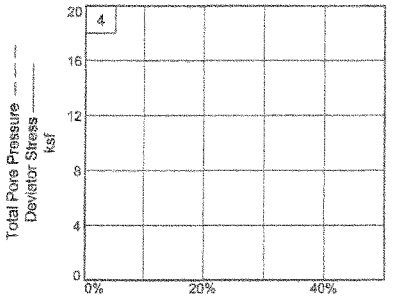
MACTEC ENGINEERING AND CONSULTING, INC.

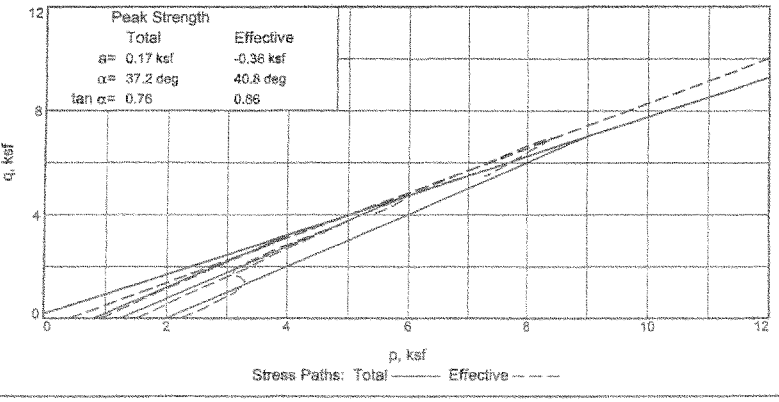
Tested By: mc **Checked By:** Rajni Sukhwani











Client: Nodarse and Associates
Project: Material Testing-Nodarse
Sample Number: CU-90%-B
Project No.: 6738-05-4573

Reviewed By _____ MACTEC Engineering and Consulting, Inc.

Tested By: mc _____ Checked By: _____

TRIAXIAL COMPRESSION TEST 6/16/2005
CU with Pore Pressures 10:29 AM

Date: 6-15-05
Client: Nodarse and Associates
Project: Material Testing-Nodarse
Project No.: 6738-05-4573
Sample Number: CU-90%-B
Description: Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments
Remarks:
Type of Sample: remold
Specific Gravity=2.762 LL= PL= PI=
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	276.340			1296.900
Moisture content: Dry soil+tare, gms.	244.810			1117.500
Moisture content: Tare, gms.	50.150			115.570
Moisture, %	16.2	24.0	22.5	17.9
Moist specimen weight, gms.	1101.8			
Diameter, in.	2.84	2.84	2.82	
Area, in.²	6.33	6.33	6.23	
Height, in.	5.50	5.50	5.46	
Net decrease in height, in.		0.00	0.04	
Wet Density, pcf	120.5	128.6	130.2	
Dry density, pcf	103.7	103.7	106.3	
Void ratio	0.6631	0.6631	0.6225	
Saturation, %	67.5	100.0	100.0	

Test Readings for Specimen No. 1

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Consolidation cell pressure = 55.60 psi (8.01 ksf)
Consolidation back pressure = 50.00 psi (7.20 ksf)
Consolidation effective confining stress = 0.81 ksf
Strain rate, in./min. = 0.05
Fail. Stress = 6.33 ksf at reading no. 15

App A Annex G-1 Test Readings for Specim Geological Investigations North of Redline

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	0.92	0.92	1.00	49.20	0.92	0.00
1	0.0010	1.00	3.3	0.0	0.08	0.92	1.00	1.08	49.20	0.96	0.04
2	0.0050	5.00	16.6	0.1	0.38	0.92	1.30	1.42	49.20	1.11	0.19
3	0.0100	24.00	79.5	0.2	1.83	0.86	2.70	3.12	49.60	1.78	0.92
4	0.0150	39.00	129.2	0.3	2.98	0.86	3.84	4.45	49.60	2.35	1.49
5	0.0200	46.00	152.4	0.4	3.51	0.85	4.36	5.13	49.70	2.60	1.75
6	0.0250	52.00	172.3	0.5	3.96	0.85	4.81	5.66	49.70	2.83	1.98
7	0.0300	57.00	188.8	0.5	4.34	0.84	5.18	6.20	49.80	3.01	2.17
8	0.0350	61.00	202.1	0.6	4.64	0.84	5.48	6.56	49.80	3.16	2.32
9	0.0400	60.00	198.8	0.7	4.56	0.84	5.40	6.46	49.80	3.12	2.28
10	0.0450	62.00	205.4	0.8	4.71	0.84	5.54	6.64	49.80	3.19	2.35
11	0.0500	64.00	212.0	0.9	4.86	0.84	5.69	6.81	49.80	3.26	2.43
12	0.0750	70.00	231.9	1.4	5.29	0.84	6.12	7.33	49.80	3.48	2.64
13	0.1000	74.00	245.2	1.8	5.56	0.84	6.40	7.66	49.80	3.62	2.78
14	0.1250	80.00	265.0	2.3	5.98	0.85	6.83	8.04	49.70	3.84	2.99
15	0.1500	85.00	281.6	2.7	6.33	0.85	7.18	8.45	49.70	4.01	3.16
16	0.1750	84.00	278.3	3.2	6.23	0.85	7.07	8.33	49.70	3.96	3.11
17	0.2000	84.00	278.3	3.7	6.20	0.85	7.05	8.29	49.70	3.95	3.10
18	0.2500	84.00	278.3	4.6	6.14	0.85	6.99	8.22	49.70	3.92	3.07
19	0.3000	83.00	275.0	5.5	6.01	0.85	6.85	8.07	49.70	3.85	3.00
20	0.3500	83.00	275.0	6.4	5.95	0.85	6.80	8.00	49.70	3.82	2.97
21	0.4000	84.00	278.3	7.3	5.96	0.85	6.81	8.01	49.70	3.83	2.98
22	0.5000	85.00	281.6	9.2	5.91	0.85	6.76	7.96	49.70	3.81	2.96
23	0.6000	84.00	278.3	11.0	5.72	0.86	6.59	7.62	49.60	3.73	2.86
24	0.7000	84.00	278.3	12.8	5.61	0.86	6.47	7.49	49.60	3.67	2.80
25	0.8000	84.00	278.3	14.7	5.49	0.86	6.35	7.35	49.60	3.61	2.74
26	0.9000	84.00	278.3	16.5	5.37	0.86	6.23	7.22	49.60	3.55	2.69
27	1.0000	84.00	278.3	18.3	5.25	0.88	6.13	6.98	49.50	3.50	2.63
28	1.1000	85.00	281.6	20.2	5.20	0.86	6.06	7.01	49.60	3.46	2.60
29	1.2000	86.00	284.9	22.0	5.14	0.88	6.01	6.85	49.50	3.45	2.57

MACTEC Engineering and Consulting, Inc.

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	276.340			1291.100
Moisture content: Dry soil+tare, gms.	244.810			1113.500
Moisture content: Tare, gms.	50.150			115.000
Moisture, %	16.2	23.8	22.4	17.8
Moist specimen weight, gms.	1104.7			
Diameter, in.	2.84	2.84	2.82	
Area, in.^{2}	6.33	6.33	6.23	
Height, in.	5.50	5.50	5.46	
Net decrease in height, in.		0.00	0.04	
Wet Density, pcf	120.8	128.7	130.4	
Dry density, pcf	104.0	104.0	106.5	
Void ratio	0.6587	0.6587	0.6191	
Saturation, %	67.9	100.0	100.0	

Test Readings for Specimen No. 2

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm^2
Membrane thickness = 0.02 cm
Consolidation cell pressure = 58.60 psi (8.44 ksf)
Consolidation back pressure = 50.00 psi (7.20 ksf)
Consolidation effective confining stress = 1.24 ksf
Strain rate, in./min. = 0.05
Fail. Stress = 9.55 ksf **at reading no.** 19

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	1.50	1.50	1.00	48.20	1.50	0.00
1	0.0010	6.00	19.9	0.0	0.46	1.50	1.96	1.31	48.20	1.73	0.23
2	0.0050	23.00	76.2	0.1	1.76	1.43	3.18	2.23	48.70	2.30	0.88
3	0.0100	34.00	112.6	0.2	2.60	1.41	4.01	2.84	48.80	2.71	1.30
4	0.0150	42.00	139.1	0.3	3.21	1.41	4.62	3.27	48.80	3.01	1.60
5	0.0200	50.00	165.7	0.4	3.81	1.40	5.21	3.73	48.90	3.30	1.91
6	0.0250	58.00	192.2	0.5	4.42	1.35	5.77	4.26	49.20	3.56	2.21
7	0.0300	64.00	212.0	0.5	4.87	1.32	6.20	4.68	49.40	3.76	2.44
8	0.0350	70.00	231.9	0.6	5.32	1.31	6.63	5.06	49.50	3.97	2.66
9	0.0400	80.00	265.0	0.7	6.08	1.30	7.37	5.69	49.60	4.33	3.04
10	0.0450	88.00	291.5	0.8	6.68	1.28	7.96	6.21	49.70	4.62	3.34
11	0.0500	97.00	321.4	0.9	7.36	1.27	8.62	6.80	49.80	4.95	3.68
12	0.0750	102.00	337.9	1.4	7.70	1.25	8.95	7.15	49.90	5.10	3.85
13	0.1000	112.00	371.1	1.8	8.41	1.24	9.65	7.79	50.00	5.45	4.21
14	0.1250	120.00	397.6	2.3	8.97	1.24	10.21	8.25	50.00	5.73	4.49
15	0.1500	124.00	410.8	2.7	9.23	1.25	10.48	8.37	49.90	5.87	4.61
16	0.1750	126.00	417.4	3.2	9.33	1.27	10.60	8.37	49.80	5.93	4.67
17	0.2000	128.00	424.1	3.7	9.44	1.27	10.70	8.45	49.80	5.99	4.72
18	0.2500	130.00	430.7	4.6	9.49	1.27	10.76	8.49	49.80	6.01	4.75
19	0.3000	132.00	437.3	5.5	9.55	1.28	10.83	8.45	49.70	6.06	4.77
20	0.3500	133.00	440.6	6.4	9.53	1.28	10.81	8.43	49.70	6.04	4.76
21	0.4000	133.00	440.6	7.3	9.43	1.30	10.73	8.28	49.60	6.01	4.72
22	0.5000	134.00	443.9	9.2	9.32	1.32	10.64	8.03	49.40	5.98	4.66
23	0.6000	133.00	440.6	11.0	9.06	1.35	10.41	7.69	49.20	5.88	4.53

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
24	0.7000	132.00	437.3	12.8	8.81	1.38	10.19	7.37	49.00	5.79	4.40
25	0.8000	133.00	440.6	14.7	8.69	1.41	10.10	7.16	48.80	5.75	4.34
26	0.9000	134.00	443.9	16.5	8.56	1.41	9.98	7.07	48.80	5.69	4.28
27	1.0000	135.00	447.3	18.3	8.44	1.41	9.85	6.98	48.80	5.63	4.22
28	1.1000	136.00	450.6	20.2	8.31	1.43	9.74	6.83	48.70	5.58	4.16
29	1.2000	134.00	443.9	22.0	8.00	1.43	9.43	6.61	48.70	5.43	4.00

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	276.340			1252.000
Moisture content: Dry soil+tare, gms.	244.810			1083.200
Moisture content: Tare, gms.	50.150			121.200
Moisture, %	16.2	23.9	22.1	17.5
Moist specimen weight, gms.	1060.9			
Diameter, in.	2.84	2.84	2.81	
Area, in.²	6.33	6.33	6.21	
Height, in.	5.29	5.29	5.24	
Net decrease in height, in.		0.00	0.05	
Wet Density, pcf	120.6	128.6	130.7	
Dry density, pcf	103.8	103.8	107.1	
Void ratio	0.6612	0.6612	0.6107	
Saturation, %	67.7	100.0	100.0	

Test Readings for Specimen No. 3

Load ring constant = 3.313 lbs. per input unit

Membrane modulus = 0.124105 kN/cm²

Membrane thickness = 0.02 cm

Consolidation cell pressure = 63.90 psi (9.20 ksf)

Consolidation back pressure = 50.00 psi (7.20 ksf)

Consolidation effective confining stress = 2.00 ksf

Strain rate, in./min. = 0.05

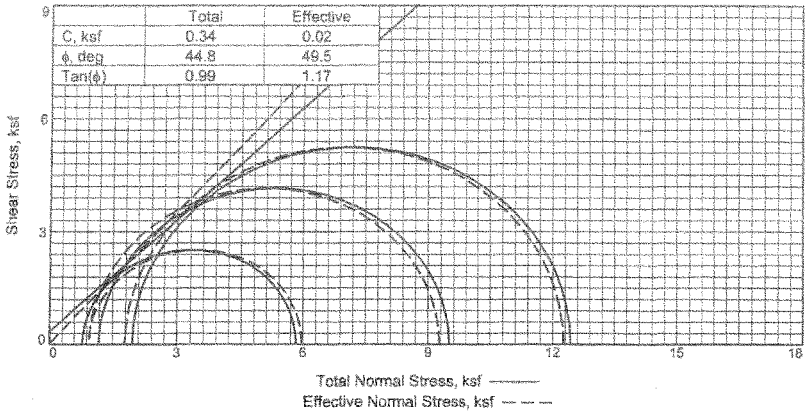
Fail. Stress = 13.92 ksf at reading no. 20

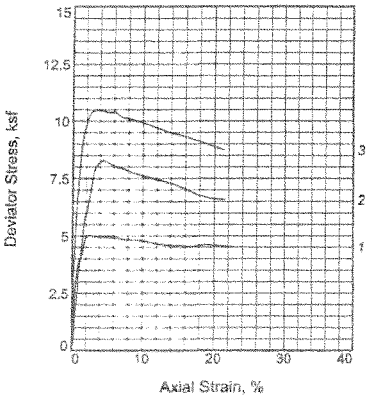
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	2.25	2.25	1.00	48.30	2.25	0.00
1	0.0010	9.00	29.8	0.0	0.69	2.25	2.94	1.31	48.30	2.59	0.35
2	0.0050	26.00	86.1	0.1	2.00	2.13	4.13	1.94	49.10	3.13	1.00
3	0.0100	33.00	109.3	0.2	2.53	1.99	4.52	2.27	50.10	3.25	1.27
4	0.0150	38.00	125.9	0.3	2.91	1.84	4.76	2.58	51.10	3.30	1.46
5	0.0200	40.00	132.5	0.4	3.06	1.71	4.78	2.79	52.00	3.25	1.53
6	0.0250	42.00	139.1	0.5	3.21	1.61	4.83	2.99	52.70	3.22	1.61
7	0.0300	43.00	142.5	0.6	3.29	1.47	4.76	3.24	53.70	3.11	1.64
8	0.0350	45.00	149.1	0.7	3.44	1.38	4.82	3.49	54.30	3.10	1.72
9	0.0400	47.00	155.7	0.8	3.59	1.31	4.90	3.74	54.80	3.10	1.79
10	0.0450	49.00	162.3	0.9	3.73	1.25	4.99	3.98	55.20	3.12	1.87
11	0.0500	50.00	165.7	1.0	3.81	1.21	5.02	4.15	55.50	3.11	1.90
12	0.0750	68.00	225.3	1.4	5.15	1.15	6.30	5.47	55.90	3.73	2.58
13	0.1000	94.00	311.4	1.9	7.09	1.24	8.33	6.72	55.30	4.78	3.54

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Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
14	0.1250	125.00	414.1	2.4	9.38	1.27	10.65	8.40	55.10	5.96	4.69
15	0.1500	146.00	483.7	2.9	10.90	1.31	12.21	9.32	54.80	6.76	5.45
16	0.1750	176.00	583.1	3.3	13.08	1.34	14.42	10.77	54.60	7.88	6.54
17	0.2000	180.00	596.3	3.8	13.31	1.37	14.68	10.73	54.40	8.02	6.65
18	0.2500	185.00	612.9	4.8	13.54	1.40	14.94	10.70	54.20	8.17	6.77
19	0.3000	192.00	636.1	5.7	13.92	1.43	15.34	10.76	54.00	8.38	6.96
20	0.3500	194.00	642.7	6.7	13.92	1.45	15.37	10.57	53.80	8.41	6.96
21	0.4000	194.00	642.7	7.6	13.78	1.50	15.27	10.20	53.50	8.39	6.89
22	0.5000	193.00	639.4	9.5	13.42	1.56	14.98	9.63	53.10	8.27	6.71
23	0.6000	190.00	629.5	11.5	12.93	1.58	14.52	9.17	52.90	8.05	6.47
24	0.7000	188.00	622.8	13.4	12.52	1.64	14.16	8.63	52.50	7.90	6.26
25	0.8000	187.00	619.5	15.3	12.18	1.68	13.86	8.23	52.20	7.77	6.09
26	0.9000	185.00	612.9	17.2	11.78	1.73	13.51	7.82	51.90	7.62	5.89
27	1.0000	183.00	606.3	19.1	11.38	1.77	13.15	7.43	51.60	7.46	5.69
28	1.1000	181.00	599.7	21.0	10.99	1.80	12.79	7.11	51.40	7.30	5.50
29	1.2000	185.00	612.9	22.9	10.96	1.79	12.75	7.14	51.50	7.27	5.48





Sample No.		1	2	3
Initial	Water Content,	16.3	16.3	16.3
	Dry Density, pcf	103.7	103.7	103.6
	Saturation,	68.0	68.1	67.8
	Void Ratio	0.6626	0.6624	0.6650
	Diameter, in.	2.84	2.84	2.84
	Height, in.	5.35	5.62	5.66
At Test	Water Content,	22.1	22.9	23.3
	Dry Density, pcf	107.0	105.6	104.9
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.6116	0.6323	0.6430
	Diameter, in.	2.81	2.82	2.83
	Height, in.	5.29	5.59	5.63
Strain rate, in./min.		0.05	0.05	0.05
Back Pressure, ksf		7.2	7.2	7.2
Cell Pressure, ksf		8.0	8.4	9.2
Fail. Stress, ksf		5.0	8.3	10.5
Total Pore Pr., ksf		7.1	7.4	7.4
Ult. Stress, ksf				
Total Pore Pr., ksf				
$\bar{\sigma}_1$ Failure, ksf		6.0	9.3	12.3
$\bar{\sigma}_3$ Failure, ksf		1.0	1.0	1.8

Type of Test: CU with Pore Pressures
Sample Type: remold
Description: Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments

Specific Gravity= 2.762
Remarks:

Reviewed By _____

Client: Nodarse and Associates

Project: Material Testing-Nodarse

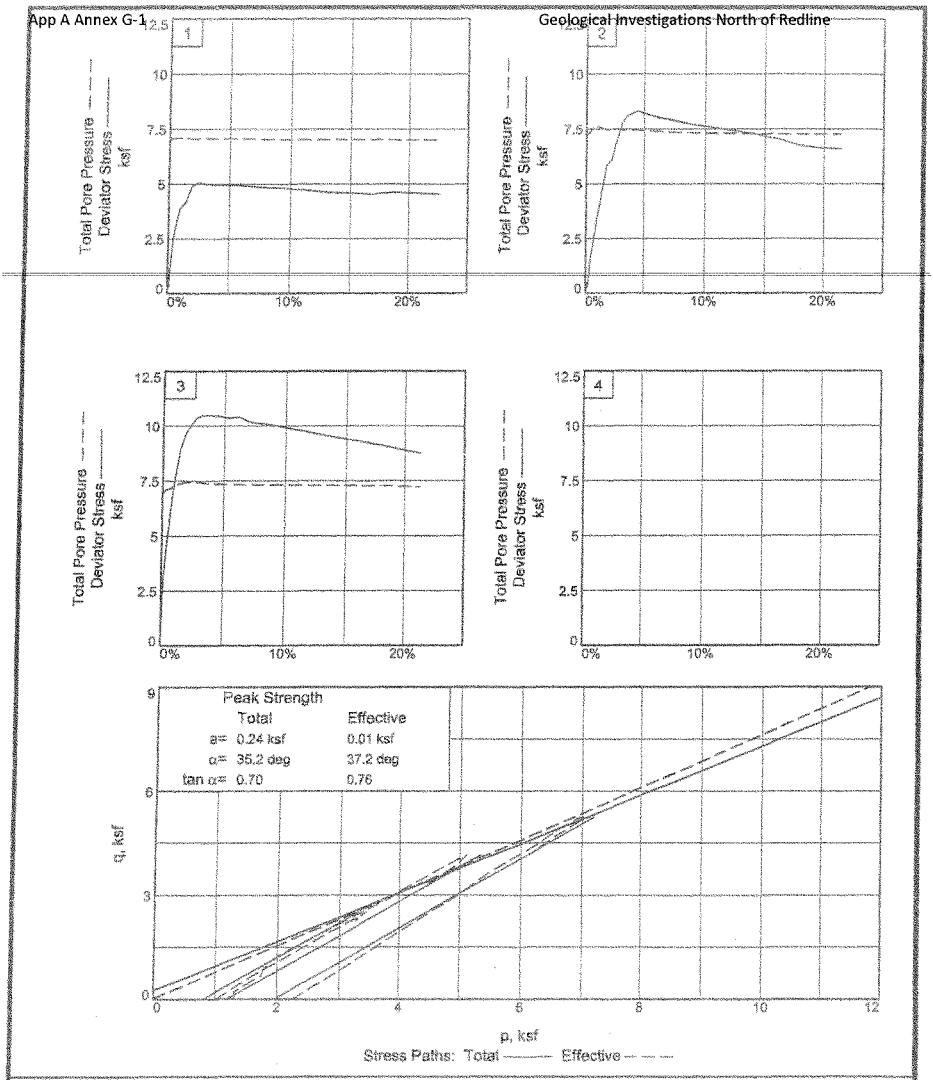
Sample Number: CU-90%-A

Proj. No.: 6738-05-4573 **Date:** 6-14-05

TRIAXIAL SHEAR TEST REPORT

MACTEC ENGINEERING AND CONSULTING, INC.

Tested By: mc **Checked By:** Kajri Sukhwani



Client: Nodarse and Associates
Project: Material Testing-Nodarse
Sample Number: CU-90%-A
Project No.: 6738-05-4573

Reviewed By _____ MACTEC Engineering and Consulting, Inc.

Tested By: mc _____ **Checked By:** _____

TRIAXIAL COMPRESSION TEST 6/16/2005
CU with Pore Pressures 10:07 AM

Date: 6-14-05
Client: Nodarse and Associates
Project: Material Testing-Nodarse
Project No.: 6738-05-4573
Sample Number: CU-90%-A
Description: Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments
Remarks:
Type of Sample: remold
Specific Gravity=2.762 LL= PL= PI=
Test Method: COE uniform strain

Paramaters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	238.320			1187.000
Moisture content: Dry soil+tare, gms.	212.600			1009.800
Moisture content: Tare, gms.	55.000			115.150
Moisture, %	16.3	24.0	22.1	19.8
Moist specimen weight, gms.	1073.2			
Diameter, in.	2.84	2.84	2.81	
Area, in.²	6.33	6.33	6.20	
Height, in.	5.35	5.35	5.29	
Net decrease in height, in.		0.00	0.06	
Wet Density, pcf	120.6	128.6	130.7	
Dry density, pcf	103.7	103.7	107.0	
Void ratio	0.6626	0.6626	0.6116	
Saturation, %	68.0	100.0	100.0	

Test Readings for Specimen No. 1

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Consolidation cell pressure = 55.60 psi (8.01 ksf)
Consolidation back pressure = 50.00 psi (7.20 ksf)
Consolidation effective confining stress = 0.81 ksf
Strain rate, in./min. = 0.05
Fail. Stress = 5.03 ksf at reading no. 14

MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	1.01	1.01	1.00	48.60	1.01	0.00
1	0.0010	3.00	9.9	0.0	0.23	1.01	1.24	1.23	48.60	1.12	0.12
2	0.0050	4.00	13.3	0.1	0.31	1.01	1.32	1.30	48.60	1.16	0.15
3	0.0100	14.00	46.4	0.2	1.07	0.95	2.02	2.13	49.00	1.49	0.54
4	0.0150	23.00	76.2	0.3	1.76	0.94	2.70	2.88	49.10	1.82	0.88
5	0.0200	31.00	102.7	0.4	2.37	0.94	3.31	3.54	49.10	2.12	1.19
6	0.0250	36.00	119.3	0.5	2.76	0.94	3.69	3.94	49.10	2.31	1.38
7	0.0300	40.00	132.5	0.6	3.06	0.94	3.99	4.27	49.10	2.47	1.53
8	0.0350	43.00	142.5	0.7	3.28	0.94	4.22	4.51	49.10	2.58	1.64
9	0.0400	46.00	152.4	0.8	3.51	0.92	4.43	4.81	49.20	2.68	1.76
10	0.0450	49.00	162.3	0.8	3.74	0.92	4.66	5.05	49.20	2.79	1.87
11	0.0500	51.00	169.0	0.9	3.88	0.92	4.81	5.21	49.20	2.86	1.94
12	0.0750	55.00	182.2	1.4	4.17	0.94	5.11	5.45	49.10	3.02	2.08
13	0.1000	65.00	215.3	1.9	4.90	0.95	5.85	6.16	49.00	3.40	2.45
14	0.1250	67.00	222.0	2.4	5.03	0.95	5.98	6.29	49.00	3.47	2.52
15	0.1500	67.00	222.0	2.8	5.01	0.95	5.96	6.27	49.00	3.45	2.50
16	0.1750	67.00	222.0	3.3	4.98	0.95	5.93	6.24	49.00	3.44	2.49
17	0.2000	67.00	222.0	3.8	4.96	0.95	5.91	6.22	49.00	3.43	2.48
18	0.3000	68.00	225.3	5.7	4.93	0.95	5.88	6.19	49.00	3.42	2.47
19	0.4000	68.00	225.3	7.6	4.83	0.98	5.81	5.94	48.80	3.40	2.42
20	0.5000	69.00	228.6	9.4	4.80	0.99	5.80	5.84	48.70	3.40	2.40
21	0.6000	69.00	228.6	11.3	4.70	0.99	5.70	5.73	48.70	3.35	2.35
22	0.7000	69.00	228.6	13.2	4.60	0.99	5.60	5.63	48.70	3.30	2.30
23	0.8000	70.00	231.9	15.1	4.57	0.99	5.56	5.60	48.70	3.28	2.28
24	0.9000	71.00	235.2	17.0	4.53	0.99	5.52	5.56	48.70	3.26	2.27
25	1.0000	74.00	245.2	18.9	4.62	1.01	5.62	5.58	48.60	3.32	2.31
26	1.1000	75.00	248.5	20.8	4.57	1.01	5.58	5.53	48.60	3.29	2.28
27	1.2000	76.00	251.8	22.7	4.52	1.01	5.53	5.48	48.60	3.27	2.26

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	238.320			1262.200
Moisture content: Dry soil+tare, gms.	212.600			1068.100
Moisture content: Tare, gms.	55.000			108.400
Moisture, %	16.3	24.0	22.9	20.2
Moist specimen weight, gms.	1127.5			
Diameter, in.	2.84	2.84	2.82	
Area, in.²	6.33	6.33	6.26	
Height, in.	5.62	5.62	5.59	
Net decrease in height, in.		0.00	0.03	
Wet Density, pcf	120.7	128.6	129.8	
Dry density, pcf	103.7	103.7	105.6	
Void ratio	0.6624	0.6624	0.6323	
Saturation, %	68.1	100.0	100.0	

Test Readings for Specimen No. 2

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Consolidation cell pressure = 58.30 psi (8.40 ksf)
Consolidation back pressure = 50.00 psi (7.20 ksf)
Consolidation effective confining stress = 1.20 ksf
Strain rate, in./min. = 0.05
Fail. Stress = 8.30 ksf at reading no. 18

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	1.31	1.31	1.00	49.20	1.31	0.00
1	0.0010	1.00	3.3	0.0	0.08	1.27	1.34	1.06	49.50	1.31	0.04
2	0.0050	3.00	9.9	0.1	0.23	1.20	1.42	1.19	50.00	1.31	0.11
3	0.0100	5.00	16.6	0.2	0.38	1.11	1.49	1.34	50.60	1.30	0.19
4	0.0150	8.00	26.5	0.3	0.61	1.09	1.70	1.56	50.70	1.40	0.30
5	0.0200	18.00	59.6	0.4	1.37	1.07	2.43	2.28	50.90	1.75	0.68
6	0.0250	22.00	72.9	0.4	1.67	0.94	2.61	2.78	51.80	1.77	0.83
7	0.0300	26.00	86.1	0.5	1.97	0.86	2.84	3.28	52.30	1.85	0.99
8	0.0350	30.00	99.4	0.6	2.27	0.79	3.06	3.87	52.80	1.93	1.14
9	0.0400	34.00	112.6	0.7	2.57	0.78	3.35	4.31	52.90	2.06	1.29
10	0.0450	38.00	125.9	0.8	2.87	0.78	3.65	4.70	52.90	2.21	1.44
11	0.0500	43.00	142.5	0.9	3.25	0.79	4.04	5.10	52.80	2.42	1.62
12	0.0750	60.00	198.8	1.3	4.51	0.85	5.36	6.31	52.40	3.11	2.26
13	0.1000	78.00	258.4	1.8	5.84	0.94	6.78	7.24	51.80	3.86	2.92
14	0.1250	82.00	271.7	2.2	6.11	0.91	7.02	7.74	52.00	3.96	3.06
15	0.1500	94.00	311.4	2.7	6.97	0.92	7.90	8.57	51.90	4.41	3.49
16	0.1750	105.00	347.9	3.1	7.75	0.94	8.69	9.28	51.80	4.81	3.88
17	0.2000	110.00	364.4	3.6	8.09	0.95	9.04	9.51	51.70	4.99	4.04
18	0.2500	114.00	377.7	4.5	8.30	0.96	9.27	9.60	51.60	5.12	4.15
19	0.3000	113.00	374.4	5.4	8.15	0.99	9.15	9.20	51.40	5.07	4.08
20	0.3500	112.00	371.1	6.3	8.00	1.02	9.03	8.83	51.20	5.02	4.00
21	0.4000	112.00	371.1	7.2	7.93	1.05	8.98	8.54	51.00	5.01	3.96
22	0.5000	111.00	367.7	9.0	7.70	1.08	8.78	8.13	50.80	4.93	3.85
23	0.6000	111.00	367.7	10.7	7.55	1.09	8.65	7.90	50.70	4.87	3.78

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Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
24	0.7000	111.00	367.7	12.5	7.40	1.11	8.51	7.68	50.60	4.81	3.70
25	0.8000	111.00	367.7	14.3	7.25	1.12	8.37	7.45	50.50	4.75	3.63
26	0.9000	110.00	364.4	16.1	7.03	1.14	8.17	7.18	50.40	4.65	3.52
27	1.0000	108.00	357.8	17.9	6.76	1.15	7.91	6.87	50.30	4.53	3.38
28	1.1000	108.00	357.8	19.7	6.61	1.14	7.75	6.81	50.40	4.44	3.31
29	1.2000	110.00	364.4	21.5	6.58	1.14	7.72	6.79	50.40	4.43	3.29

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	238.320			1285.300
Moisture content: Dry soil+tare, gms.	212.600			1102.400
Moisture content: Tare, gms.	55.000			115.700
Moisture, %	16.3	24.1	23.3	18.5
Moist specimen weight, gms.	1133.7			
Diameter, in.	2.84	2.84	2.83	
Area, in.²	6.33	6.33	6.28	
Height, in.	5.66	5.66	5.63	
Net decrease in height, in.		0.00	0.03	
Wet Density, pcf	120.5	128.5	129.4	
Dry density, pcf	103.6	103.6	104.9	
Void ratio	0.6650	0.6650	0.6430	
Saturation, %	67.8	100.0	100.0	

Test Readings for Specimen No. 3

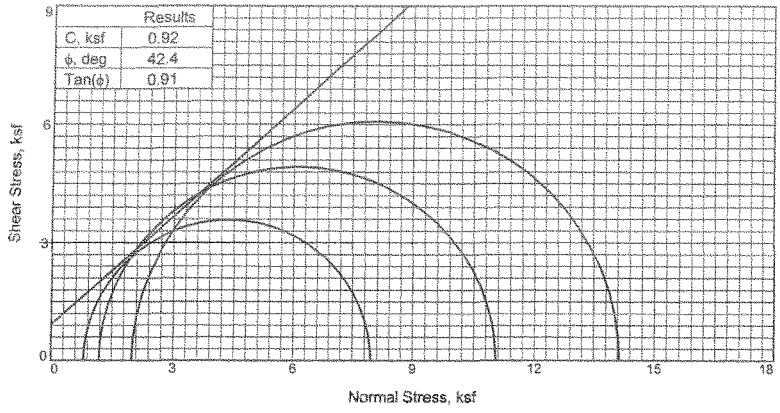
Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Consolidation cell pressure = 63.60 psi (9.16 ksf)
Consolidation back pressure = 50.00 psi (7.20 ksf)
Consolidation effective confining stress = 1.96 ksf
Strain rate, in./min. = 0.05
Fail. Stress = 10.48 ksf at reading no. 16

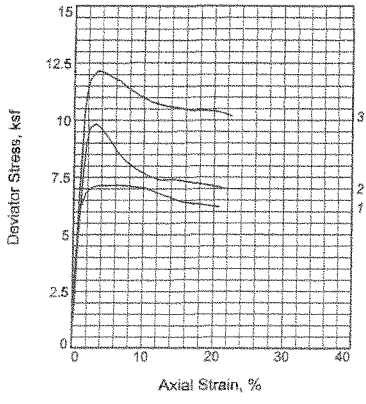
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	2.25	2.25	1.00	48.00	2.25	0.00
1	0.0010	4.00	13.3	0.0	0.30	2.25	2.55	1.14	48.00	2.40	0.15
2	0.0050	22.00	72.9	0.1	1.67	2.19	3.86	1.76	48.40	3.02	0.84
3	0.0100	42.00	139.1	0.2	3.19	2.10	5.29	2.52	49.00	3.70	1.59
4	0.0150	50.00	165.7	0.3	3.79	2.07	5.86	2.83	49.20	3.97	1.89
5	0.0200	58.00	192.2	0.4	4.39	2.04	6.44	3.15	49.40	4.24	2.20
6	0.0250	66.00	218.7	0.4	4.99	2.02	7.01	3.48	49.60	4.51	2.50
7	0.0300	73.00	241.8	0.5	5.52	2.02	7.53	3.74	49.60	4.77	2.76
8	0.0350	80.00	265.0	0.6	6.04	1.99	8.03	4.04	49.80	5.01	3.02
9	0.0450	91.00	301.5	0.8	6.86	1.89	8.75	4.64	50.50	5.32	3.43
10	0.0500	97.00	321.4	0.9	7.30	1.84	9.15	4.96	50.80	5.50	3.65
11	0.0750	119.00	394.2	1.3	8.92	1.80	10.72	5.96	51.10	6.26	4.46
12	0.1000	129.00	427.4	1.8	9.63	1.74	11.37	6.53	51.50	6.56	4.81
13	0.1250	135.00	447.3	2.2	10.03	1.73	11.76	6.80	51.60	6.74	5.02

MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
14	0.1500	140.00	463.8	2.7	10.35	1.73	12.08	6.99	51.60	6.91	5.18
15	0.1750	142.00	470.4	3.1	10.45	1.74	12.20	7.00	51.50	6.97	5.23
16	0.2000	143.00	473.8	3.5	10.48	1.79	12.27	6.87	51.20	7.03	5.24
17	0.2500	144.00	477.1	4.4	10.46	1.80	12.26	6.81	51.10	7.03	5.23
18	0.3000	144.00	477.1	5.3	10.36	1.83	12.19	6.66	50.90	7.01	5.18
19	0.3500	146.00	483.7	6.2	10.40	1.83	12.23	6.69	50.90	7.03	5.20
20	0.4000	144.00	477.1	7.1	10.16	1.84	12.01	6.51	50.80	6.93	5.08
21	0.5000	145.00	480.4	8.9	10.04	1.84	11.88	6.45	50.80	6.86	5.02
22	0.6000	145.00	480.4	10.6	9.84	1.86	11.70	6.30	50.70	6.78	4.92
23	0.7000	145.00	480.4	12.4	9.65	1.87	11.52	6.15	50.60	6.70	4.82
24	0.8000	145.00	480.4	14.2	9.45	1.87	11.33	6.05	50.60	6.60	4.73
25	0.9000	146.00	483.7	16.0	9.32	1.89	11.21	5.94	50.50	6.55	4.66
26	1.0000	146.00	483.7	17.7	9.12	1.90	11.03	5.80	50.40	6.46	4.56
27	1.1000	146.00	483.7	19.5	8.93	1.92	10.84	5.66	50.30	6.38	4.46
28	1.2000	146.00	483.7	21.3	8.73	1.93	10.66	5.52	50.20	6.30	4.37





Sample No.		1	2	3
Initial	Water Content,	15.7	15.6	15.4
	Dry Density, pcf	110.6	109.4	109.4
	Saturation,	77.3	75.1	73.9
	Void Ratio	0.5596	0.5756	0.5765
	Diameter, in.	2.84	2.84	2.84
	Height, in.	5.77	5.64	5.32
At Test	Water Content,	20.3	19.5	20.0
	Dry Density, pcf	110.6	112.0	111.0
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.5596	0.5398	0.5534
	Diameter, in.	2.84	2.82	2.83
	Height, in.	5.77	5.60	5.29
Strain rate, in./min.		0.05	0.05	0.05
Back Pressure, ksf		0.0	0.0	0.0
Cell Pressure, ksf		0.8	1.2	2.0
Fail. Stress, ksf		7.1	9.9	12.1
Ult. Stress, ksf				
σ_1 Failure, ksf		8.0	11.0	14.1
σ_3 Failure, ksf		0.8	1.2	2.0

Type of Test: Unconsolidated Undrained
Sample Type: remold
Description: Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments

Specific Gravity= 2.762
Remarks:

Reviewed By _____

Client: Nodarse and Associates

Project: Material Testing-Nodarse

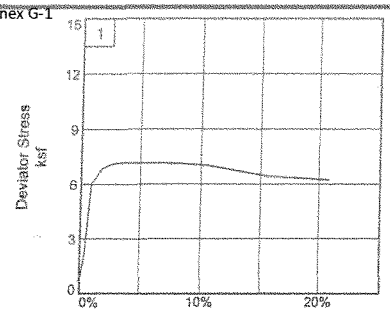
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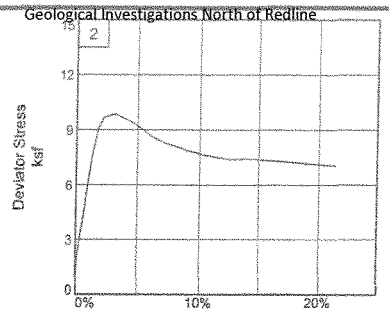
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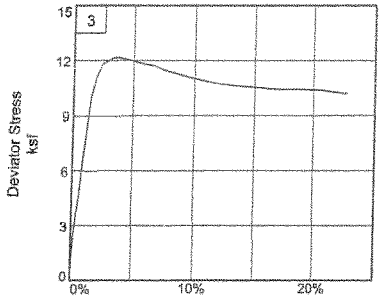
TRIAXIAL SHEAR TEST REPORT

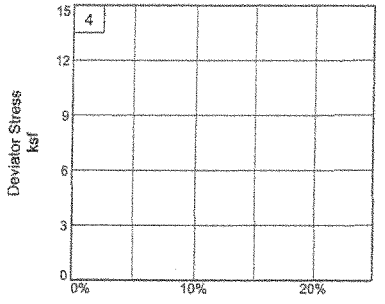
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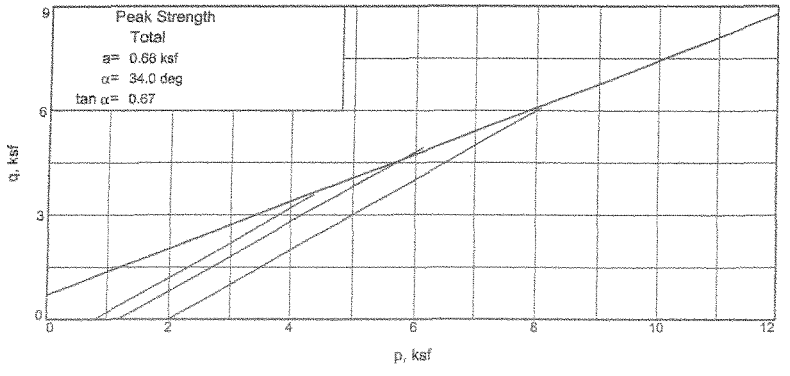
Tested By: mc **Checked By:** Rajni Sukhwani











Client: Nodarse and Associates
Project: Material Testing-Nodarse
Sample Number: UU-95%-A
Project No.: 6738-05-4573

Reviewed By _____ MACTEC Engineering and Consulting, Inc.

Tested By: mc _____ **Checked By:** _____

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

6/15/2005
10:46 AM

Date:	6-11-05
Client:	Nodarse and Associates
Project:	Material Testing-Nodarse
Project No.:	6738-05-4573
Sample Number:	UU-95%-A
Description:	Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments
Remarks:	
Type of Sample:	remold
Specific Gravity=2.762	LL= PL= PI=
Test Method:	COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	224.300		1320.500
Moisture content: Dry soil+tare, gms.	200.660		1168.100
Moisture content: Tare, gms.	49.750		230.100
Moisture, %	15.7	20.3	16.2
Moist specimen weight, gms.	1226.9		
Diameter, in.	2.84	2.84	
Area, in.^{2}	6.33	6.33	
Height, in.	5.77	5.77	
Net decrease in height, in.		0.00	
Wet Density, pcf	127.9	133.0	
Dry density, pcf	110.6	110.6	
Void ratio	0.5596	0.5596	
Saturation, %	77.3	100.0	

Test Readings for Specimen No. 1

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm^2
Membrane thickness = 0.02 cm
Cell pressure = 5.60 psi (0.81 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 7.15 ksf at reading no. 21

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	0.81	0.81	1.00		0.81
1	0.0010	5.00	16.6	0.0	0.38	0.81	1.18	1.47		0.99
2	0.0050	12.00	39.8	0.1	0.90	0.81	1.71	2.12		1.26
3	0.0100	17.00	56.3	0.2	1.28	0.81	2.08	2.58		1.45
4	0.0150	22.00	72.9	0.3	1.65	0.81	2.46	3.05		1.63
5	0.0200	26.00	86.1	0.3	1.95	0.81	2.76	3.42		1.78
6	0.0250	35.00	116.0	0.4	2.62	0.81	3.43	4.25		2.12
7	0.0300	44.00	145.8	0.5	3.30	0.81	4.10	5.09		2.45
8	0.0350	53.00	175.6	0.6	3.97	0.81	4.77	5.92		2.79
9	0.0400	62.00	205.4	0.7	4.64	0.81	5.44	6.75		3.12
10	0.0450	71.00	235.2	0.8	5.31	0.81	6.11	7.58		3.46
11	0.0500	81.00	268.4	0.9	6.05	0.81	6.85	8.50		3.83
12	0.0750	86.00	284.9	1.3	6.39	0.81	7.20	8.93		4.00
13	0.1000	92.00	304.8	1.7	6.81	0.81	7.61	9.44		4.21
14	0.1250	94.00	311.4	2.2	6.93	0.81	7.73	9.59		4.27
15	0.1500	96.00	318.0	2.6	7.04	0.81	7.85	9.73		4.33
16	0.1750	97.00	321.4	3.0	7.08	0.81	7.89	9.78		4.35
17	0.2000	98.00	324.7	3.5	7.12	0.81	7.93	9.84		4.37
18	0.2500	99.00	328.0	4.3	7.13	0.81	7.94	9.85		4.37
19	0.3000	100.00	331.3	5.2	7.14	0.81	7.95	9.85		4.38
20	0.3500	101.00	334.6	6.1	7.14	0.81	7.95	9.86		4.38
21	0.4000	102.00	337.9	6.9	7.15	0.81	7.96	9.87		4.38
22	0.5000	103.00	341.2	8.7	7.08	0.81	7.89	9.79		4.35
23	0.6000	104.00	344.6	10.4	7.02	0.81	7.82	9.70		4.32
24	0.7000	103.00	341.2	12.1	6.82	0.81	7.62	9.45		4.21
25	0.8000	102.00	337.9	13.9	6.62	0.81	7.42	9.21		4.11
26	0.9000	101.00	334.6	15.6	6.42	0.81	7.23	8.96		4.02
27	1.0000	102.00	337.9	17.3	6.35	0.81	7.16	8.87		3.98
28	1.1000	103.00	341.2	19.1	6.28	0.81	7.08	8.79		3.95
29	1.2000	104.00	344.6	20.8	6.20	0.81	7.01	8.69		3.91

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	165.540		1261.000
Moisture content: Dry soil+tare, gms.	150.080		1103.500
Moisture content: Tare, gms.	51.290		109.000
Moisture, %	15.6	19.5	15.8
Moist specimen weight, gms.	1186.9		
Diameter, in.	2.84	2.82	
Area, in.²	6.33	6.24	
Height, in.	5.64	5.60	
Net decrease in height, in.		0.04	
Wet Density, pcf	126.6	133.9	
Dry density, pcf	109.4	112.0	
Void ratio	0.5756	0.5398	
Saturation, %	75.1	100.0	

Test Readings for Specimen No. 2

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Cell pressure = 8.30 psi (1.20 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 9.85 ksf at reading no. 16

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	1.20	1.20	1.00		1.20
1	0.0010	8.00	26.5	0.0	0.61	1.20	1.81	1.51		1.50
2	0.0050	18.00	59.6	0.1	1.38	1.20	2.57	2.15		1.88
3	0.0100	30.00	99.4	0.2	2.29	1.20	3.49	2.92		2.34
4	0.0150	36.00	119.3	0.3	2.75	1.20	3.94	3.30		2.57
5	0.0200	42.00	139.1	0.4	3.20	1.20	4.40	3.68		2.80
6	0.0250	47.00	155.7	0.4	3.58	1.20	4.77	3.99		2.98
7	0.0300	51.00	169.0	0.5	3.88	1.20	5.07	4.25		3.13
8	0.0350	56.00	185.5	0.6	4.26	1.20	5.45	4.56		3.32
9	0.0400	62.00	205.4	0.7	4.71	1.20	5.90	4.94		3.55
10	0.0450	67.00	222.0	0.8	5.08	1.20	6.28	5.25		3.74
11	0.0500	74.00	245.2	0.9	5.61	1.20	6.80	5.69		4.00
12	0.0750	102.00	337.9	1.3	7.70	1.20	8.89	7.44		5.04
13	0.1000	120.00	397.6	1.8	9.01	1.20	10.21	8.54		5.70
14	0.1250	129.00	427.4	2.2	9.65	1.20	10.84	9.07		6.02
15	0.1500	131.00	434.0	2.7	9.75	1.20	10.95	9.16		6.07
16	0.1750	133.00	440.6	3.1	9.85	1.20	11.05	9.24		6.12
17	0.2000	132.00	437.3	3.6	9.73	1.20	10.93	9.14		6.06
18	0.2500	129.00	427.4	4.5	9.42	1.20	10.62	8.89		5.91
19	0.3000	125.00	414.1	5.4	9.05	1.20	10.24	8.57		5.72
20	0.3500	120.00	397.6	6.3	8.60	1.20	9.80	8.20		5.50
21	0.4000	117.00	387.6	7.1	8.31	1.20	9.50	7.95		5.35
22	0.5000	113.00	374.4	8.9	7.87	1.20	9.07	7.58		5.13
23	0.6000	111.00	367.7	10.7	7.58	1.20	8.77	7.34		4.98
24	0.7000	110.00	364.4	12.5	7.36	1.20	8.56	7.16		4.88

MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
25	0.8000	113.00	374.4	14.3	7.41	1.20	8.60	7.20		4.90
26	0.9000	114.00	377.7	16.1	7.32	1.20	8.51	7.12		4.85
27	1.0000	115.00	381.0	17.9	7.22	1.20	8.42	7.04		4.81
28	1.1000	116.00	384.3	19.7	7.13	1.20	8.32	6.96		4.76
29	1.2000	117.00	387.6	21.4	7.03	1.20	8.22	6.88		4.71

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	178.450		1186.300
Moisture content: Dry soil+tare, gms.	161.940		1039.700
Moisture content: Tare, gms.	54.840		106.200
Moisture, %	15.4	20.0	15.7
Moist specimen weight, gms.	1116.7		
Diameter, in.	2.84	2.83	
Area, in.²	6.33	6.27	
Height, in.	5.32	5.29	
Net decrease in height, in.		0.03	
Wet Density, pcf	126.2	133.2	
Dry density, pcf	109.4	111.0	
Void ratio	0.5765	0.5534	
Saturation, %	73.9	100.0	

Test Readings for Specimen No. 3

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Cell pressure = 13.90 psi (2.00 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 12.15 ksf at reading no. 17

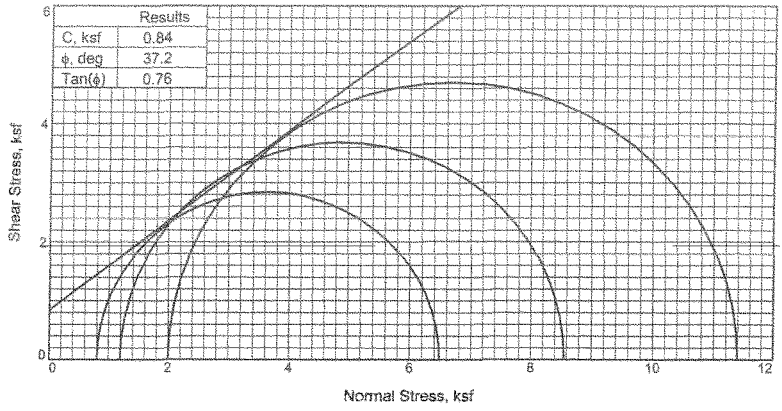
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	2.00	2.00	1.00		2.00
1	0.0010	6.00	19.9	0.0	0.46	2.00	2.46	1.23		2.23
2	0.0050	20.00	66.3	0.1	1.52	2.00	3.52	1.76		2.76
3	0.0100	32.00	106.0	0.2	2.43	2.00	4.43	2.21		3.22
4	0.0150	40.00	132.5	0.3	3.03	2.00	5.04	2.52		3.52
5	0.0200	48.00	159.0	0.4	3.64	2.00	5.64	2.82		3.82
6	0.0250	55.00	182.2	0.5	4.16	2.00	6.16	3.08		4.08
7	0.0300	62.00	205.4	0.6	4.69	2.00	6.69	3.34		4.35
8	0.0350	71.00	235.2	0.7	5.36	2.00	7.37	3.68		4.68
9	0.0400	80.00	265.0	0.8	6.04	2.00	8.04	4.02		5.02
10	0.0450	89.00	294.9	0.9	6.71	2.00	8.71	4.35		5.36
11	0.0500	96.00	318.0	0.9	7.23	2.00	9.23	4.61		5.62
12	0.0750	133.00	440.6	1.4	9.97	2.00	11.97	5.98		6.99
13	0.1000	150.00	497.0	1.9	11.19	2.00	13.19	6.59		7.60
14	0.1250	159.00	526.8	2.4	11.81	2.00	13.81	6.90		7.91
15	0.1500	162.00	536.7	2.8	11.97	2.00	13.97	6.98		7.99

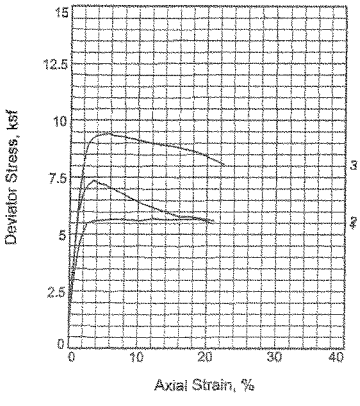
MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
16	0.1750	165.00	546.6	3.3	12.13	2.00	14.14	7.06		8.07
17	0.2000	166.00	550.0	3.8	12.15	2.00	14.15	7.07		8.08
18	0.2500	166.00	550.0	4.7	12.03	2.00	14.03	7.01		8.02
19	0.3000	165.00	546.6	5.7	11.84	2.00	13.84	6.91		7.92
20	0.3500	165.00	546.6	6.6	11.72	2.00	13.72	6.85		7.86
21	0.4000	163.00	540.0	7.6	11.46	2.00	13.46	6.73		7.73
22	0.5000	161.00	533.4	9.4	11.09	2.00	13.09	6.54		7.55
23	0.6000	160.00	530.1	11.3	10.79	2.00	12.79	6.39		7.40
24	0.7000	161.00	533.4	13.2	10.63	2.00	12.63	6.31		7.31
25	0.8000	163.00	540.0	15.1	10.52	2.00	12.53	6.26		7.26
26	0.9000	165.00	546.6	17.0	10.42	2.00	12.42	6.20		7.21
27	1.0000	169.00	559.9	18.9	10.43	2.00	12.43	6.21		7.21
28	1.1000	172.00	569.8	20.8	10.36	2.00	12.36	6.18		7.18
29	1.2000	173.00	573.1	22.7	10.17	2.00	12.18	6.08		7.09

App A Annex G-1 Geological Investigations North of Redline





Sample No.		1	2	3
Initial	Water Content,	16.6	16.6	16.6
	Dry Density, pcf	104.1	103.8	104.0
	Saturation,	69.9	69.4	69.7
	Void Ratio	0.6562	0.6605	0.6579
	Diameter, in.	2.84	2.84	2.84
	Height, in.	5.78	5.72	5.36
At Test	Water Content,	22.9	22.8	23.0
	Dry Density, pcf	105.7	105.9	105.4
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.6313	0.6284	0.6357
	Diameter, in.	2.83	2.82	2.83
	Height, in.	5.75	5.68	5.34
Strain rate, in./min.		0.05	0.05	0.05
Back Pressure, ksf		0.0	0.0	0.0
Cell Pressure, ksf		0.8	1.2	2.0
Fail. Stress, ksf		5.7	7.4	9.4
Ult. Stress, ksf				
σ_1 Failure, ksf		6.5	8.6	11.4
σ_3 Failure, ksf		0.8	1.2	2.0

Type of Test: Unconsolidated Undrained
Sample Type: remolded
Description: Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments

Specific Gravity= 2.762
Remarks:

Reviewed By _____

Client: Nodarse and Associates

Project: Material Testing-Nodarse

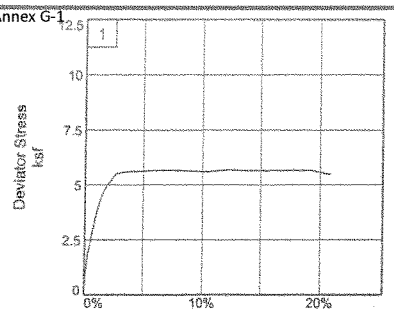
Sample Number: UU-90%-A

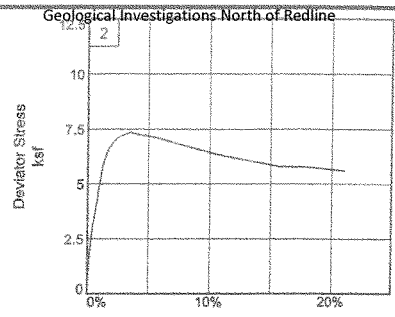
Proj. No.: 6738-05-4573 **Date:** 6-10-05

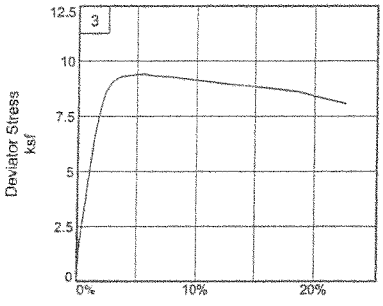
TRIAXIAL SHEAR TEST REPORT

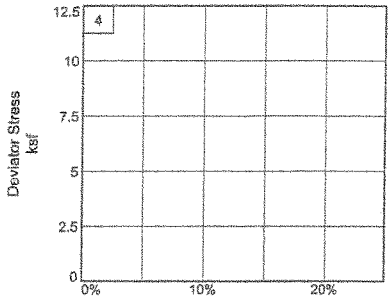
MACTEC ENGINEERING AND CONSULTING, INC.

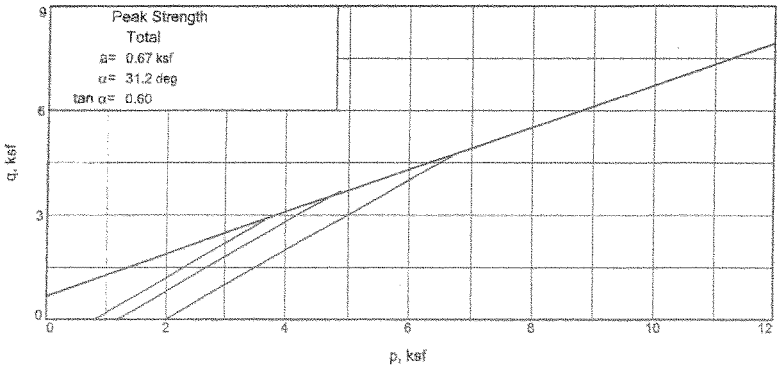
Tested By: mc **Checked By:** Rajni Sukhwani











Client: Nodarse and Associates
Project: Material Testing-Nodarse
Sample Number: UU-90%-A
Project No.: 6738-05-4573

Reviewed By _____ MACTEC Engineering and Consulting, Inc.

Tested By: mc _____ **Checked By:** _____

TRIAXIAL COMPRESSION TEST
Unconsolidated Undrained

6/15/2005
10:45 AM

Date:	6-10-05
Client:	Nodarse and Associates
Project:	Material Testing-Nodarse
Project No.:	6738-05-4573
Sample Number:	UU-90%-A
Description:	Tan Slightly Clayey Silty Medium to Fine SAND with Shell and Rock Fragments
Remarks:	
Type of Sample:	remolded
Specific Gravity=2.762	LL= PL= PI=
Test Method:	COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	178.470		1181.000
Moisture content: Dry soil+tare, gms.	160.220		1025.700
Moisture content: Tare, gms.	50.320		115.200
Moisture, %	16.6	22.9	17.1
Moist specimen weight, gms.	1166.8		
Diameter, in.	2.84	2.83	
Area, in.^{2}	6.33	6.27	
Height, in.	5.78	5.75	
Net decrease in height, in.		0.03	
Wet Density, pcf	121.4	129.9	
Dry density, pcf	104.1	105.7	
Void ratio	0.6562	0.6313	
Saturation, %	69.9	100.0	

Test Readings for Specimen No. 1

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm^2
Membrane thickness = 0.02 cm
Cell pressure = 5.60 psi (0.81 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 5.68 ksf at reading no. 23

MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	0.81	0.81	1.00		0.81
1	0.0010	3.00	9.9	0.0	0.23	0.81	1.03	1.28		0.92
2	0.0050	12.00	39.8	0.1	0.91	0.81	1.72	2.13		1.26
3	0.0100	18.00	59.6	0.2	1.37	0.81	2.17	2.70		1.49
4	0.0150	24.00	79.5	0.3	1.82	0.81	2.63	3.26		1.72
5	0.0200	27.00	89.5	0.3	2.05	0.81	2.85	3.54		1.83
6	0.0250	30.00	99.4	0.4	2.27	0.81	3.08	3.82		1.94
7	0.0300	34.00	112.6	0.5	2.57	0.81	3.38	4.19		2.09
8	0.0350	37.00	122.6	0.6	2.80	0.81	3.60	4.47		2.21
9	0.0400	40.00	132.5	0.7	3.02	0.81	3.83	4.75		2.32
10	0.0450	43.00	142.5	0.8	3.25	0.81	4.05	5.02		2.43
11	0.0500	46.00	152.4	0.9	3.47	0.81	4.28	5.30		2.54
12	0.0750	58.00	192.2	1.3	4.35	0.81	5.16	6.40		2.98
13	0.1000	65.00	215.3	1.7	4.86	0.81	5.67	7.03		3.24
14	0.1500	74.00	245.2	2.6	5.48	0.81	6.29	7.80		3.55
15	0.1750	75.00	248.5	3.0	5.53	0.81	6.34	7.86		3.57
16	0.2000	76.00	251.8	3.5	5.58	0.81	6.39	7.92		3.60
17	0.2500	77.00	255.1	4.3	5.60	0.81	6.41	7.95		3.61
18	0.3000	78.00	258.4	5.2	5.62	0.81	6.43	7.97		3.62
19	0.3500	79.00	261.7	6.1	5.64	0.81	6.45	8.00		3.63
20	0.4000	80.00	265.0	7.0	5.66	0.81	6.47	8.02		3.64
21	0.5000	81.00	268.4	8.7	5.63	0.81	6.43	7.98		3.62
22	0.6000	82.00	271.7	10.4	5.59	0.81	6.39	7.93		3.60
23	0.7000	85.00	281.6	12.2	5.68	0.81	6.49	8.04		3.65
24	0.8000	86.00	284.9	13.9	5.63	0.81	6.44	7.98		3.62
25	0.9000	88.00	291.5	15.6	5.65	0.81	6.45	8.00		3.63
26	1.0000	90.00	298.2	17.4	5.66	0.81	6.46	8.01		3.63
27	1.1000	92.00	304.8	19.1	5.66	0.81	6.47	8.02		3.64
28	1.2000	91.00	301.5	20.9	5.48	0.81	6.28	7.79		3.55

MACTEC Engineering and Consulting, Inc.

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	178.470		1253.500
Moisture content: Dry soil+tare, gms.	160.220		1090.600
Moisture content: Tare, gms.	50.320		116.400
Moisture, %	16.6	22.8	16.7
Moist specimen weight, gms.	1151.7		
Diameter, in.	2.84	2.82	
Area, in.²	6.33	6.25	
Height, in.	5.72	5.68	
Net decrease in height, in.		0.04	
Wet Density, pcf	121.1	130.0	
Dry density, pcf	103.8	105.9	
Void ratio	0.6605	0.6284	
Saturation, %	69.4	100.0	

Test Readings for Specimen No. 2

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.02 cm
Cell pressure = 8.30 psi (1.20 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 7.36 ksf at reading no. 17

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	1.20	1.20	1.00		1.20
1	0.0010	5.00	16.6	0.0	0.38	1.20	1.58	1.32		1.39
2	0.0050	14.00	46.4	0.1	1.07	1.20	2.26	1.89		1.73
3	0.0100	24.00	79.5	0.2	1.83	1.20	3.02	2.53		2.11
4	0.0150	31.00	102.7	0.3	2.36	1.20	3.55	2.97		2.37
5	0.0200	36.00	119.3	0.4	2.74	1.20	3.93	3.29		2.56
6	0.0250	42.00	139.1	0.4	3.19	1.20	4.39	3.67		2.79
7	0.0300	45.00	149.1	0.5	3.42	1.20	4.61	3.86		2.90
8	0.0350	49.00	162.3	0.6	3.72	1.20	4.91	4.11		3.05
9	0.0400	53.00	175.6	0.7	4.02	1.20	5.21	4.36		3.20
10	0.0450	56.00	185.5	0.8	4.24	1.20	5.43	4.55		3.31
11	0.0500	61.00	202.1	0.9	4.61	1.20	5.81	4.86		3.50
12	0.0750	79.00	261.7	1.3	5.95	1.20	7.14	5.98		4.17
13	0.1000	88.00	291.5	1.8	6.60	1.20	7.79	6.52		4.49
14	0.1250	93.00	308.1	2.2	6.94	1.20	8.13	6.81		4.67
15	0.1500	96.00	318.0	2.6	7.13	1.20	8.33	6.97		4.76
16	0.1750	98.00	324.7	3.1	7.25	1.20	8.44	7.06		4.82
17	0.2000	100.00	331.3	3.5	7.36	1.20	8.56	7.16		4.88
18	0.2500	99.00	328.0	4.4	7.22	1.20	8.42	7.04		4.81
19	0.3000	99.00	328.0	5.3	7.15	1.20	8.35	6.99		4.77
20	0.3500	98.00	324.7	6.2	7.02	1.20	8.21	6.87		4.70
21	0.4000	97.00	321.4	7.0	6.88	1.20	8.08	6.76		4.64
22	0.5000	95.00	314.7	8.8	6.61	1.20	7.81	6.53		4.50
23	0.6000	93.00	308.1	10.6	6.35	1.20	7.54	6.31		4.37
24	0.7000	92.00	304.8	12.3	6.15	1.20	7.35	6.15		4.27

MACTEC Engineering and Consulting, Inc.

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
25	0.8000	91.00	301.5	14.1	5.97	1.20	7.16	5.99		4.18
26	0.9000	90.00	298.2	15.8	5.78	1.20	6.97	5.84		4.08
27	1.0000	92.00	304.8	17.6	5.78	1.20	6.98	5.84		4.09
28	1.2000	93.00	308.1	21.1	5.60	1.20	6.79	5.68		3.99

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Final
Moisture content: Moist soil+tare, gms.	178.470		1178.400
Moisture content: Dry soil+tare, gms.	160.220		1022.600
Moisture content: Tare, gms.	50.320		115.200
Moisture, %	16.6	23.0	17.2
Moist specimen weight, gms.	1080.9		
Diameter, in.	2.84	2.83	
Area, in.^{2}	6.33	6.28	
Height, in.	5.36	5.34	
Net decrease in height, in.		0.02	
Wet Density, pcf	121.3	129.7	
Dry density, pcf	104.0	105.4	
Void ratio	0.6579	0.6357	
Saturation, %	69.7	100.0	

Test Readings for Specimen No. 3

Load ring constant = 3.313 lbs. per input unit
Membrane modulus = 0.124105 kN/cm^2
Membrane thickness = 0.02 cm
Cell pressure = 13.90 psi (2.00 ksf)
Back pressure = 0.00 psi (0.00 ksf)
Strain rate, in./min. = 0.05
Fail. Stress = 9.40 ksf at reading no. 19

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
0	0.0000	0.00	0.0	0.0	0.00	2.00	2.00	1.00		2.00
1	0.0010	7.00	23.2	0.0	0.53	2.00	2.53	1.27		2.27
2	0.0050	17.00	56.3	0.1	1.29	2.00	3.29	1.64		2.65
3	0.0100	23.00	76.2	0.2	1.74	2.00	3.75	1.87		2.87
4	0.0150	28.00	92.8	0.3	2.12	2.00	4.12	2.06		3.06
5	0.0200	34.00	112.6	0.4	2.57	2.00	4.58	2.29		3.29
6	0.0250	39.00	129.2	0.5	2.95	2.00	4.95	2.47		3.48
7	0.0300	44.00	145.8	0.6	3.32	2.00	5.33	2.66		3.66
8	0.0350	48.00	159.0	0.7	3.62	2.00	5.63	2.81		3.81
9	0.0400	54.00	178.9	0.7	4.07	2.00	6.07	3.03		4.04
10	0.0450	60.00	198.8	0.8	4.52	2.00	6.52	3.26		4.26
11	0.0500	64.00	212.0	0.9	4.82	2.00	6.82	3.41		4.41
12	0.0750	89.00	294.9	1.4	6.67	2.00	8.67	4.33		5.34
13	0.1000	105.00	347.9	1.9	7.83	2.00	9.83	4.91		5.92
14	0.1250	116.00	384.3	2.3	8.61	2.00	10.61	5.30		6.31
15	0.1500	122.00	404.2	2.8	9.01	2.00	11.01	5.50		6.51
16	0.1750	125.00	414.1	3.3	9.19	2.00	11.19	5.59		6.60

MACTEC Engineering and Consulting, Inc.

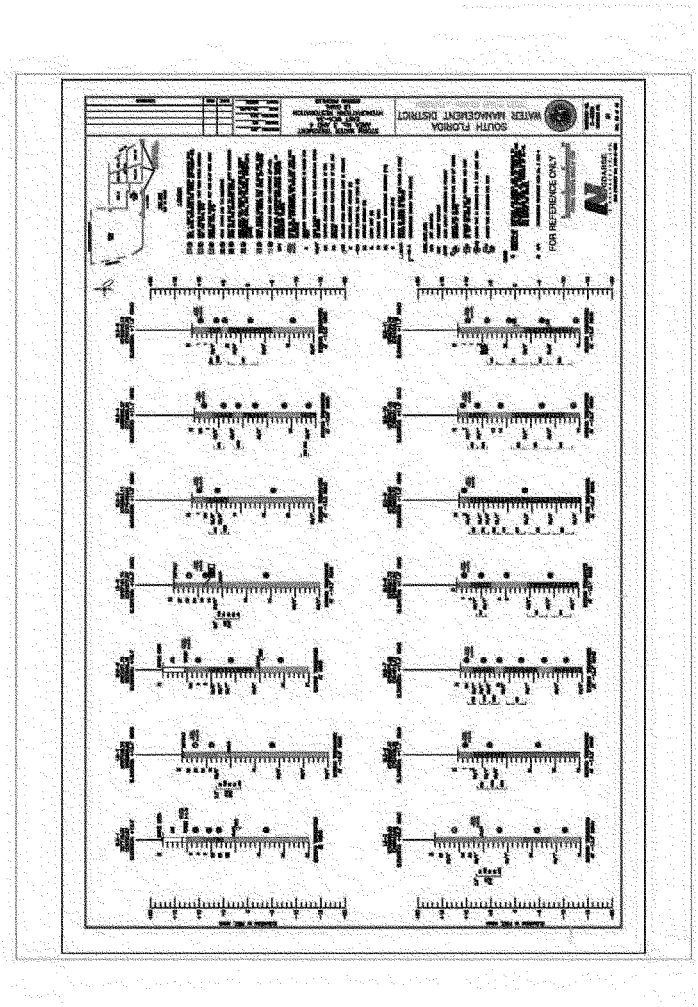
Test Readings for Specimen No. 3

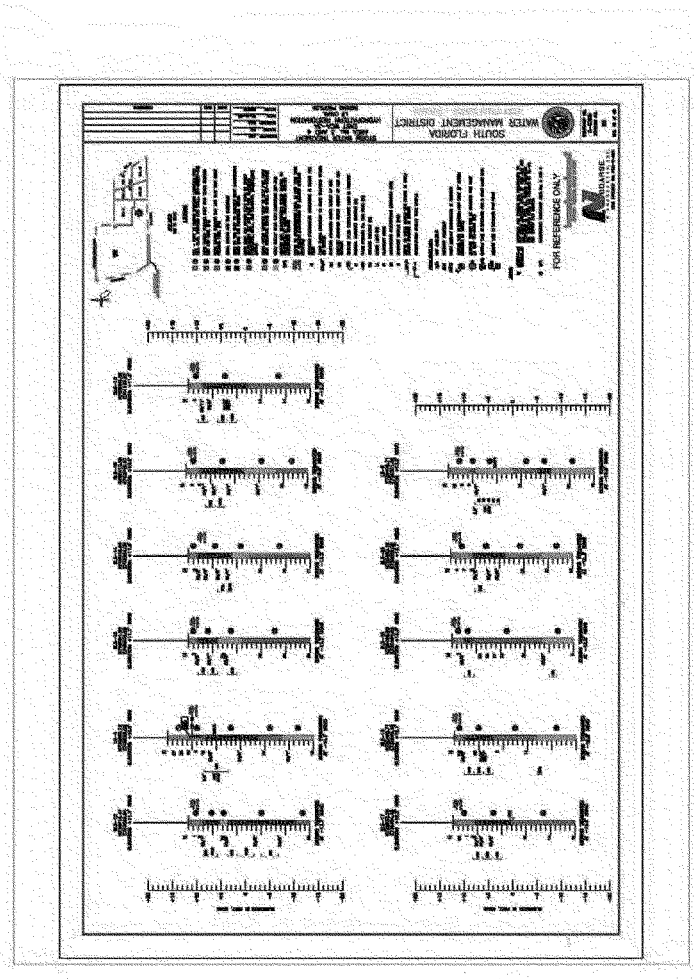
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Princ. Stress ksf	Major Princ. Stress ksf	1:3 Ratio	P ksf	Q ksf
17	0.2000	127.00	420.8	3.7	9.29	2.00	11.29	5.64		6.65
18	0.2500	129.00	427.4	4.7	9.34	2.00	11.35	5.67		6.67
19	0.3000	131.00	434.0	5.6	9.40	2.00	11.40	5.69		6.70
20	0.3500	131.00	434.0	6.6	9.30	2.00	11.30	5.65		6.65
21	0.4000	132.00	437.3	7.5	9.28	2.00	11.28	5.64		6.64
22	0.5000	133.00	440.6	9.4	9.16	2.00	11.16	5.58		6.58
23	0.6000	134.00	443.9	11.2	9.04	2.00	11.04	5.52		6.52
24	0.7000	135.00	447.3	13.1	8.91	2.00	10.91	5.45		6.46
25	0.8000	137.00	453.9	15.0	8.85	2.00	10.85	5.42		6.43
26	0.9000	138.00	457.2	16.9	8.72	2.00	10.72	5.36		6.36
27	1.0000	139.00	460.5	18.7	8.58	2.00	10.58	5.29		6.29
28	1.1000	138.00	457.2	20.6	8.32	2.00	10.33	5.16		6.16
29	1.2000	137.00	453.9	22.5	8.07	2.00	10.07	5.03		6.04

ANNEX G-2. GEOLOGICAL INVESTIGATIONS SOUTH OF THE REDLINE



Figure G-2-1. Nodarse and Associates, 2000 Boring Map


SOUTH FLORIDA
WATER MANAGEMENT DISTRICT
FOR REFERENCE ONLY



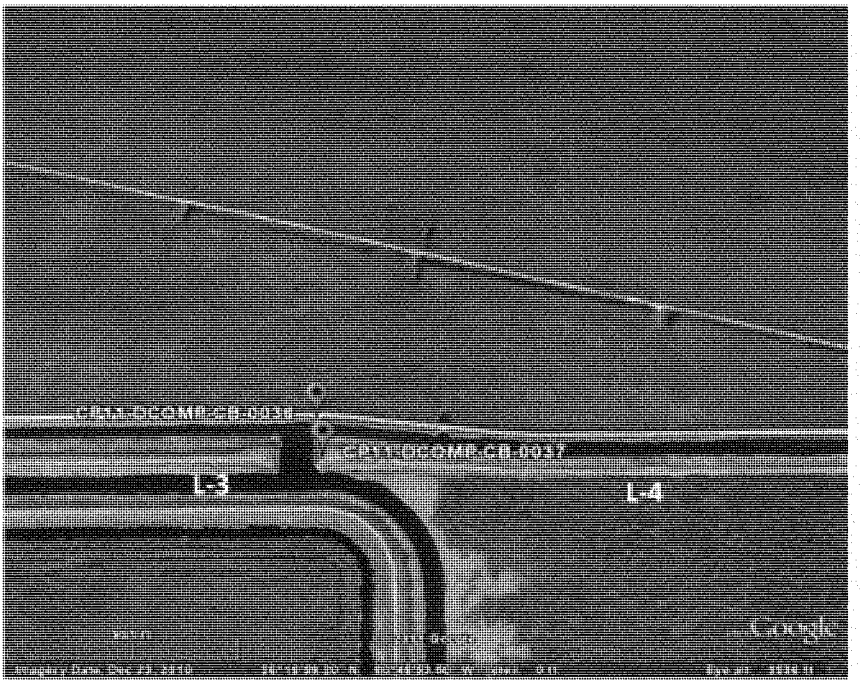


Figure G-2-2. U.S. Army Corps of Engineers 2011 Boring Map

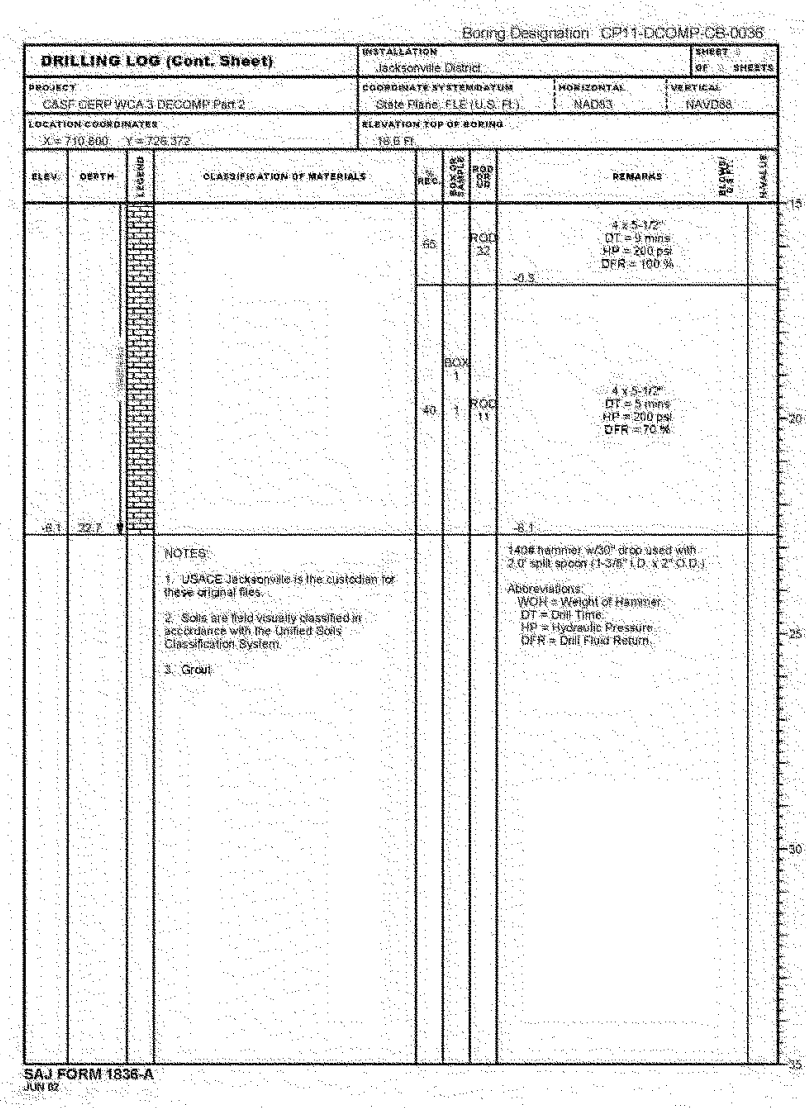
Boring Designation CP11-DCOMP-CB-0036

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 1 SHEETS
1. PROJECT: C&SF CERP WCA 3 DECOMP Part 2 L-4 North, Proposed Pump Station		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP11-DCOMP-CB-0036	LOCATION COORDINATES: X = 710,900 Y = 728,372	11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAM	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED: 1 / UNDISTURBED (UD): 0
4. NAME OF DRILLER: Charlie Brown		13. TOTAL NUMBER CORE BOXES: 1	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: 9.0 Ft.
			15. DATE BORING: STARTED 03-15-11 / COMPLETED 03-15-11
6. THICKNESS OF OVERBURDEN: N/A			16. ELEVATION TOP OF BORING: 16.6 Ft.
7. DEPTH DRILLED INTO ROCK: N/A			17. TOTAL RECOVERY FOR BORING: 69 %
8. TOTAL DEPTH OF BORING: 22.7 Ft.			18. SIGNATURE AND TITLE OF INSPECTOR: Michael Fitzhams, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR BAG/CORE NO.	ROD CORE OD	REMARKS	BLOWS/6 IN.	M-VALUE
16.6	0.0						16.6		
			FILL, fine grained sand with some fine and coarse grained gravel, trace clay, 2.5YR 6/2 pale red	73			SPT Sampler	8 15 16	31
13.6	3.0			60			15.1 SPT Sampler	4 7 9	16
			SAND, clayey, some fine gravel, trace silt, 5Y 4/1 dark gray (SC)	80			13.6 SPT Sampler	5 5 3	8
10.6	6.0			73			12.1 SPT Sampler	3 3 5	8
9.1	7.5		CLAY, organic-L, moist, organic soil with calcareous sand and gravel particles, 5Y 2.5/1 black (OL)	87			10.6 SPT Sampler	2 1 1	2
			SAND, clayey, moist, calcareous sand and gravel fragments, 7.5YR 2.5/1 black (SC)	53			9.1 SPT Sampler	WOH 1 1	2
7.1	9.5			93			7.6 SPT Sampler	2 1 4	5
6.1	10.5		CLAY, lean, moist, some calcareous gravel, little organics, 10YR 4/1 dark gray (CL)	87			6.1 SPT Sampler	3 2 4	6
4.6	12.0		SAND, clayey, trace gravel, trace silt, 2.5Y 6/1 gray (SC)	40			4.6 SPT Sampler	2 4 16	20
3.1	13.5		SAND, silty, some coarse gravel, 2.5Y 6/1 gray (SM)	65	BOX 1	ROD 32	3.1 4 x 5-1/2" DT = 9 mins HP = 200 psi DFR = 100 %		
			LIMESTONE, fossiliferous, weathered, moderately fractured, vuggy, glaconitic staining, some clay infills, 5Y 8/1 white						

SAJ FORM 1836
JUN 02

(Continued)



Boring Designation: CP11-DCOMP-CB-0036

DRILLING LOG (Cont. Sheet)

INSTALLATION: Jacksonville District			SHEET OF SHEETS
PROJECT: CASF CERP WCA 3 DECOMP Part 2	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83	VERTICAL: NAVD88
LOCATION COORDINATES: X = 710,880 Y = 726,372	ELEVATION TOP OF BORING: 18.6 Ft.		

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX/RUN	RQD/REC	REMARKS	WATER LEVEL READINGS
				65		RQD 32	4 x 5-1/2" DT = 9 mins HP = 200 psi DFR = 100 %	
							-0.5	
				40	BOX 1 / 1	RQD 11	4 x 5-1/2" DT = 5 mins HP = 200 psi DFR = 70 %	
-8.1	22.7						-8.1	
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Grout				140# hammer, w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.) Abbreviations: WOH = Weight of Hammer DT = Drill Time HP = Hydraulic Pressure DFR = Drill Fluid Return	

15 20 25 30 35

SAJ FORM 1836-A
JUN 02

Boring Designation CP11-DCOMP-CB-0037

DRILLING LOG

DIVISION	South Atlantic
INSTALLATION	Jacksonville District
SHEET	OF SHEETS
1. PROJECT	C&SF CERP WCA 3 DECOMP Part 2 L-4 South, Proposed Pump Station Alternate
2. BORING DESIGNATION	CP11-DCOMP-CB-0037
LOCATION COORDINATES	X = 710,839 Y = 726,187
3. DRILLING AGENCY	Corps of Engineers - CESAM
CONTRACTOR FILE NO.	
4. NAME OF DRILLER	Charlie Brown
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	N/A
7. DEPTH DRILLED INTO ROCK	N/A
8. TOTAL DEPTH OF BORING	20.7 Ft.
9. SIZE AND TYPE OF BIT	See Remarks
10. COORDINATE SYSTEM/DATUM	State Plane, FLE (U.S. Ft.) / NAD83
HORIZONTAL	NAD83
VERTICAL	NAVD88
11. MANUFACTURER'S DESIGNATION OF DRILL	Failing 1500
☐ AUTO HAMMER ☒ MANUAL HAMMER	
12. TOTAL SAMPLES	DISTURBED 1 / UNDISTURBED (UD) 0
13. TOTAL NUMBER CORE BOXES	1
14. ELEVATION GROUND WATER	8.3 Ft.
15. DATE BORING	STARTED 03-22-11 / COMPLETED 03-23-11
16. ELEVATION TOP OF BORING	20.0 Ft.
17. TOTAL RECOVERY FOR BORING	61 %
18. SIGNATURE AND TITLE OF INSPECTOR	Michael Fitzharris, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	SAMPLE OR RUN NO.	ROD OR CORE	REMARKS	BLOWS/0.5 FT.	N-VALUE
20.0	0.0						20.0		
			FILL, gravelly, trace organics, trace clay, trace roots, some shell fragments, 5YR 7/1 light gray	67			SPT Sampler	10 24 16	40
			From El. 18.5 to 14.0 Ft., sandy, trace organics, trace shell fragments, 7.5YR 4/1 dark gray	53			SPT Sampler	4 6 8	14
				87			SPT Sampler	9 10 13	23
				87			SPT Sampler	11 15 21	36
			From El. 14.0 to 12.5 Ft., gravelly, some silt, 7.5YR 5/2 brown	87			SPT Sampler	13 10 12	22
			From El. 12.5 to 11.0 Ft., sandy, 10YR 5/1 gray	0			SPT Sampler	5 6 6	12
11.0	9.0						11.0		
10.8	9.1		SAND, clayey, trace gravel, some shell fragments, 10YR 7/1 light gray (SC)						
10.7	9.3		CLAY, organic-L, low plasticity, some sand, 10YR 2/1 black (OL)	80			SPT Sampler	9 2 2	4
10.5	9.5		SAND, silty, some shell fragments, 10YR 7/2 light gray (SM)				9.5		
			CLAY, organic-H, some fibrous material, 5YR 2.5/2 dark reddish brown (OH)	100			SPT Sampler	1 2 2	4
8.0	12.0						8.0		
			SAND, silty, 10YR 2/2 very dark brown (SM)	100			SPT Sampler	weh weh weh	0
5.9	14.1						6.5		
			SAND, clayey, some gravel and silt, some shell fragments, trace organics, 10YR 5/2 grayish brown (SC)	80			SPT Sampler	2 7 7	14
							5.0		

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation CP11-DCOMP-CB-0037

DRILLING LOG (Cont. Sheet)	INSTALLATION Jacksonville District	SHEET OF SHEETS
PROJECT C&SF CERP WCA 3 DECOMP Part 2	COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.) / HORIZONTAL NAD83 / VERTICAL NAVD88	
LOCATION COORDINATES X = 710,839 Y = 726,157	ELEVATION TOP OF BORING 20.0 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD CORE	REMARKS	BLOWS PER 6 INCH	RQD/ NA
				69			SPT Sampler	1 / 4 / 50/0.3"	54+
				0			Advanced Boring		
1.9	18.1		LIMESTONE, moderately hard, moderately fractured, vuggy, 10YR 7/1 light gray	100	BOX 1	ROD 42	4 x 5-1/2" DT = 11 mins HP = 300 psi DFR = 90 %		
0.7	20.7								

NOTES:

1. USACE Jacksonville is the custodian for these original files.
2. Soils are field visually classified in accordance with the Unified Soils Classification System.
3. Grout

140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.).

Abbreviations:
WOH = Weight of Hammer,
DT = Drill Time,
HP = Hydraulic Pressure,
DFR = Drill Fluid Return.

SAJ FORM 1836-A
JUN 02



Figure G-2-3. U.S. Army Corps of Engineers 2011 Boring Map

Boring Designation CP11-DCOMP-CB-0011

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District
SHEET: OF SHEETS	
1. PROJECT: CASF CERP WCA 3 DECOMP Part 2 L-5 Canal Plug, Proposed Pump Station	9. SIZE AND TYPE OF BIT: See Remarks
	10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP11-DCOMP-CB-0011 / LOCATION COORDINATES: X = 775,757 Y = 727,006	11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1300 ☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAM / CONTRACTOR FILE NO.	12. TOTAL SAMPLES: DISTURBED 0 / UNDISTURBED (UD) 0
4. NAME OF DRILLER: Charlie Brown	13. TOTAL NUMBER CORE BOXES: 1
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED / DEG. FROM VERTICAL / BEARING	14. ELEVATION GROUND WATER: 7.0 Ft.
	15. DATE BORING: STARTED 03-22-11 / COMPLETED 03-22-11
6. THICKNESS OF OVERBURDEN: N/A	16. ELEVATION TOP OF BORING: 13.4 Ft.
7. DEPTH DRILLED INTO ROCK: N/A	17. TOTAL RECOVERY FOR BORING: 55 %
8. TOTAL DEPTH OF BORING: 27.9 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: Michael Fitzharris, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD OR CORE	REMARKS	BLOWS/0.5 FT.	N VALUE
13.4	0.0						13.4		
			FILL, sandy, some gravel, trace roots, 7.5YR 5/1 gray	100			SPT Sampler	3 50	
11.9	1.5						11.9		
			SAND, clayey, some gravel, some shell fragments, 10YR 5/1 gray (SC)	80			SPT Sampler	15 23 17	40
							10.4		
				100			SPT Sampler	14 16 16	32
							8.9		
				53			SPT Sampler	36 16 17	33
							7.4		
				87			SPT Sampler	7 7 7	14
							5.9		
				100			SPT Sampler	8 8 11	19
							4.4		
				53			SPT Sampler	28 24 6	30
2.9	10.5						2.9		
			GRAVEL, silty, some shell fragments, 10YR 6/2 light brownish gray (GM)	47			SPT Sampler	6 7 10	17
1.4	12.0						1.4		
			SAND, silty, some shell fragments, 2.5Y 7/1 light gray (SM)	67			SPT Sampler	11 5 3	8
-0.1	13.5						-0.1		
			GRAVEL, silty, trace clay, some organics, some shell fragments, 7.5YR 5/1 gray (GM)	27			SPT Sampler	2 2 2	4
							-1.6		

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation CP11-DCOMP-CB-0011

DRILLING LOG (Cont. Sheet)		INSTALLATION: Jacksonville District		SHEET: OF SHEETS
PROJECT: C&SF CERP WCA 3 DECOMP Part 2		COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83	VERTICAL: NAVD88
LOCATION COORDINATES: X = 775,757 Y = 727,006		ELEVATION TOP OF BORING: 13.4 Ft.		

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD OR CORE	REMARKS	BLOWS/0.5 FT.	N-VALUE
				7			SPT Sampler	1 / 1 / 1	2
-3.1	16.5		CLAY, organic-H, trace gravel, trace sand, some shell fragments, 2.5Y 3/1 very dark gray (OH)	40			SPT Sampler	WOH / WOH / WOH	0
-4.6	18.0		GRAVEL, silty, some organics, some shell fragments, 2.5Y 3/3 dark olive brown (GM)	33			SPT Sampler	1 / 2 / 1	3
-5.6	19.0		SAND, clayey, some gravel, some shell fragments, 2.5Y 7/3 pale yellow (SC)	33			SPT Sampler	5 / 9 / 12	21
-7.6	21.0		SAND, silty, some shell fragments, trace clay, 5Y 8/1 white (SM)	20			SPT Sampler	4 / 6 / 3	9
-10.0	23.4		LIMESTONE, fossiliferous, moderately hard, vuggy, 7.5YR 7/1 light gray	56			SPT Sampler	4 / 50/0.4"	
-14.5	27.9			57	BOX 1	ROD 8	4 x 5-1/2" DT = 6 mins HP = 200 psi DFR = 75 %		
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Grout.				140# hammer w/30" drop used with 2.0" split spoon (I-3/8" I.D. x 2" O.D.) Abbreviations: WOH = Weight of Hammer DT = Drill Time HP = Hydraulic Pressure DFR = Drill Fluid Return		

SAJ FORM 1836-A
JUN 02

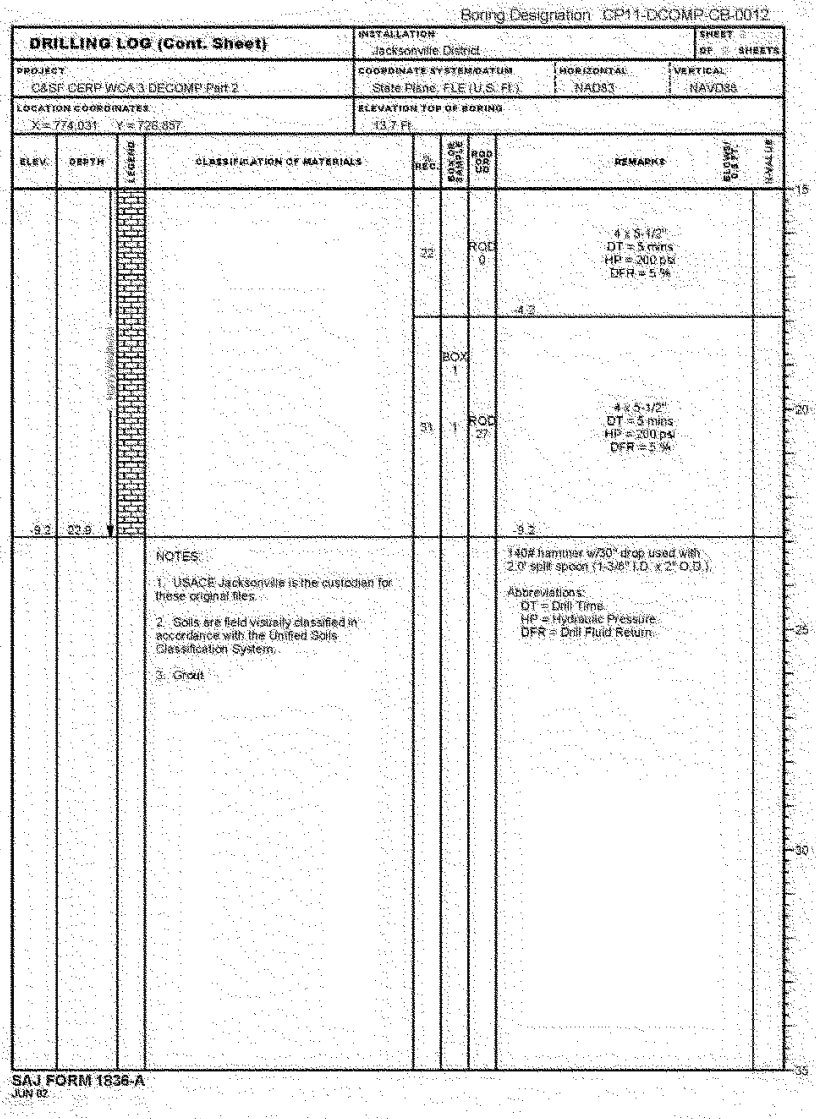
Boring Designation CP11-DCOMP-CB-0012

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
1. PROJECT: CESF CERP WCA 3 DECOMP Part 2 L-3 South	9. SIZE AND TYPE OF BIT: See Remarks		
	10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83	VERTICAL: NAVD88
2. BORING DESIGNATION: CP11-DCOMP-CB-0012	LOCATION COORDINATES: X = 774,031 Y = 726,857	11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAM	CONTRACTOR'S FILE NO.	12. TOTAL SAMPLES: 1	DISTURBED: 1 UNDISTURBED (UD): 0
4. NAME OF DRILLER: Charlie Brown		13. TOTAL NUMBER CORE BOXES: 1	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: 7.3 Ft.
		15. DATE BORING:	STARTED: 03-18-11 COMPLETED: 03-19-11
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 13.7 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: 59 %	
8. TOTAL DEPTH OF BORING: 22.9 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Michael Fitzharris, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX OR SAMPLE NO.	RQD OR CD	REMARKS	BLOWS/0.5 FT.	N-VALUE
13.7	0.0						13.7		
			FILL, sandy, some gravel, trace clay and shells, 2.5Y 6/2 light brownish gray	73			SPT Sampler	15 33 20	43
							12.2		
				60			SPT Sampler	9 9 9	18
							10.7		
				58			SPT Sampler	5 34 50	84
9.2	4.5						9.2		
8.8	4.9		SAND, silty, some shell fragments, 2.5Y 6/2 light brownish gray (SM)	57			SPT Sampler	3 4 5	9
			CLAY, organic-H, some shell fragments, 2.5Y 2.5/1 black (OH)				7.7		
7.7	6.0								
7.2	6.5		CLAY, fat, trace sand, 2.5Y 2.5/1 black (CH)	100			SPT Sampler	2 2 2	4
			CLAY, organic-H, trace sand and gravel, trace shells, 2.5Y 2.5/1 black (OH)				6.2		
				83			SPT Sampler	5 5 50/0.3	55+
5.0	8.7						5.0		
4.8	8.9		CLAY, lean, trace gravel, 2.5Y 5/1 gray (CL)	90		RQD 38	4 x 5-1/2" DT = 11 mins HP = 200 psi DFR = 40 %		
			LIMESTONE, fossiliferous, vuggy, 10YR 7/1 light gray				3.7		
			At El. 3.7 Ft., highly weathered, 10YR 6/3 pale brown	32	BOX 1	RQD 0	4 x 5-1/2" DT = 9 mins HP = 200 psi DFR = 40 %		
							0.3		
				22		RQD 0	4 x 5-1/2" DT = 5 mins HP = 200 psi DFR = 5 %		

SAJ FORM 1836
JUN 02

(Continued)



Boring Designation CP11-DCOMP-CB-0012

DRILLING LOG (Cont. Sheet)

INSTALLATION	SHEET
Jacksonville District	OF SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
C&SF CERP WCA 3 DECOMP Part 2	State Plane, FLE (U.S. Ft.)	NAD83	NAVD88

LOCATION COORDINATES	ELEVATION TOP OF BORING
X= 774,031 Y = 726,857	13.7 Ft.

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BLOWS/6 INCHES	ROD SIZE	REMARKS	BLOWS/ 0.5 FT.	HAND LIB
				22		ROD 9	4 x 5-1/2" DT = 5 mins HP = 200 psi DFR = 5 %		
							4.3		
				33	BOX 1	ROD 27	4 x 5-1/2" DT = 5 mins HP = 200 psi DFR = 5 %		
-9.2	22.9						-9.2		
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Grout				140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.). Abbreviations: DT = Drill Time HP = Hydraulic Pressure DFR = Drill Fluid Return		

15 20 25 30 35

SAJ FORM 1836-A
JUN 82

Boring Designation CP11-DCOMP-CB-0014

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
1. PROJECT: C&SF CERP WCA 3 DECOMP Part 2 L-5 South		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) HORIZONTAL: NAD83 VERTICAL: NAVD88	
2. BORING DESIGNATION: CP11-DCOMP-CB-0014	LOCATION COORDINATES: X = 770,021 Y = 726,834	11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAM	CONTRACTOR FILE NO.	12. TOTAL SAMPLES: DISTURBED 0 UNDISTURBED (UD) 0	
4. NAME OF DRILLER: Charlie Brown		13. TOTAL NUMBER CORE BOXES: 2	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL:	BEARING:	14. ELEVATION GROUND WATER: Not Encountered
		15. DATE BORING: STARTED 03-18-11 COMPLETED 03-18-11	
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 14.7 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: 70 %	
8. TOTAL DEPTH OF BORING: 21.5 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Michael Fitzhamis, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	RUN OR BOX NO.	RQD OR CORE	REMARKS	BLOWS/0.5 FT.	N-VALUE
14.7	0.0						14.7		
			FILL: sandy, mainly silty sand with some gravel, trace clay, 2.5Y 7/1 light gray	87			SPT Sampler	45 48 28	76
13.2	1.5						13.2		
				53			SPT Sampler	7 13 13	26
11.7	3.0						11.7		
			SAND: clayey, low plasticity, some silt and gravel, 2.5YR 5/1 reddish gray (SC)	100			SPT Sampler	19 50	
10.2	4.5						10.2		
9.9	4.8		SAND: silty, some clay and gravel, 10YR 6/2 light brownish gray (SM)	100			SPT Sampler	50/0.3'	
			LIMESTONE, fossiliferous, moderately hard, weathered, slightly fractured, vuggy, 7.5YR 7/1 light gray	57		ROD 0	4 x 5-1/2" DT = 14 mins HP = 300 psi DFR = 100 %		
6.9	7.8						6.9		
			At El. 5.9 Ft., highly fractured, 7.5YR 8/1 white	74	BOX 1	ROD 22	4 x 5-1/2" DT = 11 mins HP = 200 psi DFR = 80 %		
1.9	12.8						1.9		
				82		ROD 0	4 x 5-1/2" DT = 8 mins HP = 200 psi DFR = 80 %		

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation: CP11-DCOMP-CB-0014

DRILLING LOG (Cont. Sheet)

INSTALLATION	SHEET
Jacksonville District	OF SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
C&SF CERP WCA 3 DECOMP Part 2	State Plane FLE (U.S. Ft.)	NAD83	NAVD88

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 770,021 Y = 726,834	14.7 Ft

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX OR ROD RUN	REC OR CORE	REMARKS	BLOWS/0.5 FT.	N VALUE
				82	BOX 1	ROD 0	4 x 5-1/2" DT = 8 mins HP = 200 psi DFR = 80 %		
							-1.8		
				28	BOX 2	ROD 0	4 x 5-1/2" DT = 5 mins HP = 200 psi DFR = 0 %		
-6.8	21.5						-6.8		
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Grout				140# hammer w/30" drop used with 2.0' split spoon (1-3/8" I.D. x 2" O.D.). Abbreviations: DT = Drill Time HP = Hydraulic Pressure DFR = Drill Fluid Return		

15 20 25 30 35

SAJ FORM 1836-A
JUN 02

Boring Designation CP11-DCOMP-CB-0016

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
1. PROJECT: C&SF CERP WCA 3 DECOMP Part 2 L-3 South		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP11-DCOMP-CB-0016	LOCATION COORDINATES: X = 766,059 Y = 726,798	11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAM	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED: 1 / UNDISTURBED (UD): 0
4. NAME OF DRILLER: Charlie Brown		13. TOTAL NUMBER CORE BOXES: 1	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: 6.6 Ft.
		15. DATE BORING	STARTED: 03-18-11 / COMPLETED: 03-18-11
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 15.3 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: 76 %	
8. TOTAL DEPTH OF BORING: 16.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Michael Fitzharris, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC. %	BOX OR SAMPLE NO.	ROD RUN	REMARKS	BLOWS/0.5 FT.	N-VALUE
15.3	0.0						15.3		
			FILL; sandy, low plasticity, some clay; some gravel, 5Y 4/1 dark gray	80			SPT Sampler	18 23 15	38
							12.8		
				67			SPT Sampler	9 13 17	30
(2.3	3.6						12.3		
			SAND, clayey, medium plasticity, some gravel; little silt, little shells; some organics, 10YR 5/1 gray (SC)	100			SPT Sampler	13 10 12	22
			At El. 10.8 Ft., trace organics, 10YR 5/2 grayish brown				10.8		
				87			SPT Sampler	13 13 8	21
9.3	6.0						9.3		
8.7	6.6		CLAY, fat, gravelly; some coarse sand; shell fragments; some fibrous material; 10YR 2/1 black (CH)	67			SPT Sampler	4 4 2	6
			CLAY, organic H, 10YR 2/1 black (OH)				7.8		
			From El. 7.8 to 4.8 Ft., moist, trace calcareous gravel, 10YR 2/2 very dark brown	100			SPT Sampler	1 1 1	2
							6.3		
				53			SPT Sampler	1 3 2	5
4.8	10.5						4.8		
4.0	11.3		CLAY, fat, moist, some coarse-grained sand; some organics, 7.5YR 5/1 gray (CH)	63			SPT Sampler	10 50/0.3"	
			LIMESTONE, fossiliferous, moderately hard, vuggy, 10YR 7/1 light gray	70	BOX 1	RQD 45	4 x 5-1/2" HP = 200 psi DFR = 100 %		
			At El. 2.1 Ft., open aperture						

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation: CP11-DCOMP-CB-0016

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
PROJECT: C&SF CERP WCA 3 DECOMP Part 2	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 766,059 Y = 726,798	ELEVATION TOP OF BORING: 15.3 Ft	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX OR SAMPLE NO.	RQD OR CORE LOSS	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
-0.7	16.0			70	BOX 1	ROC 45	4 x 5-1/2" HP = 200 psi DFR = 100 %	-0.7	

NOTES:

1. USACE Jacksonville is the custodian for these original files.

2. Soils are field visually classified in accordance with the Unified Soils Classification System.

3. Grout

140# hammer w/30" drop used with 2.0' split spoon (1-3/8" I.D. x 2" O.D.)

Abbreviations:
HP = Hydraulic Pressure
DFR = Drill Fluid Return

SAJ FORM 1836-A
JUN 02

Boring Designation CP11-DCOMP-CB-0018

DRILLING LOG

DIVISION	South Atlantic
INSTALLATION	Jacksonville District
SHEET	OF SHEETS
1. PROJECT	CASF CERP WCA 3 DECOMP Part 2 L-3 South
2. BORING DESIGNATION	CP11-DCOMP-CB-0018
LOCATION COORDINATES	X = 791,968 Y = 726,749
3. DRILLING AGENCY	Corps of Engineers - CESAM
CONTRACTOR FILE NO.	
4. NAME OF DRILLER	Charlie Brown
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	N/A
7. DEPTH DRILLED INTO ROCK	N/A
8. TOTAL DEPTH OF BORING	13.7 Ft.
9. SIZE AND TYPE OF BIT	See Remarks
10. COORDINATE SYSTEM/DATUM	State Plane, FLE (U.S. Ft.)
HORIZONTAL	NAD83
VERTICAL	NAVD88
11. MANUFACTURER'S DESIGNATION OF DRILL	Failing 1500
☐ AUTO HAMMER ☒ MANUAL HAMMER	
12. TOTAL SAMPLES	DISTURBED 0 UNDISTURBED (UD) 0
13. TOTAL NUMBER CORE BOXES	1
14. ELEVATION GROUND WATER	7.4 Ft.
15. DATE BORING	STARTED 03-18-11 COMPLETED 03-18-11
16. ELEVATION TOP OF BORING	14.8 Ft.
17. TOTAL RECOVERY FOR BORING	61 %
18. SIGNATURE AND TITLE OF INSPECTOR	Michael Fitzhenry, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	RUN BOX SAMPLE NO.	RUN ROD CORE	REMARKS	BLOWS/0.5 FT.	N-VALUE
14.8	0.0						14.8		
			FILL, sandy, some gravel, trace roots, trace clay and shell fragments, 7.5YR 6/1 gray	86			SPT Sampler	27 48 50	98
							13.3		
				53			SPT Sampler	18 35 49	84
11.5	3.0						11.8		
			SAND, clayey, moist, some organic soil, some silt and gravel, 7.5YR 5/1 gray (SC)	100			SPT Sampler	23 18 30/0.1'	66+
10.4	4.4						10.7		
			LIMESTONE, vuggy, 10YR 7/2 light gray At El. 10.3 Ft., moderately fractured	27	BOX 1	ROD 0	DT = 4 mins HP = 200 psi DFR = 75 %		
8.3	6.5						8.3		
			CLAY, organic-H, moist, some fibrous plant material, 10YR 2/1 black (OH) ▼	43			SPT Sampler	2 4 7	11
6.8	8.0						6.8		
			LIMESTONE, intensely weathered, 10YR 5/6 yellowish brown From El. 6.4 to 5.0 Ft., fossiliferous, pitted, shell fragments, 10YR 7/2 light gray	50			6.4 SPT Sampler	50/0.4'	
			At El. 5.0 Ft., moderately fractured	68	BOX 1	ROD 33	DT = 8 mins HP = 200 psi DFR = 80 %		
1.1	13.7						1.1		
			NOTES 1. USACE Jacksonville is the custodian for				140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.)		

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation CP11-DCOMP-CB-0018

DRILLING LOG (Cont. Sheet)	INSTALLATION Jacksonville District	SHEET OF SHEETS
PROJECT C&SF CERP WCA 3 DECOMP Part 2	COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.)	HORIZONTAL NAD83 / VERTICAL NAVD88
LOCATION COORDINATES X = 761,968 Y = 726,749	ELEVATION TOP OF BORING 14.8 Ft	

ELEV.	DEPTH	GRAPHIC LOG	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD USE	REMARKS	BLOWS PER 6"	HVALUE
			these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Grout				Abbreviations: DT = Drill Time HP = Hydraulic Pressure DFR = Drill Fluid Return		

SAJ FORM 1836-A
JUN 02

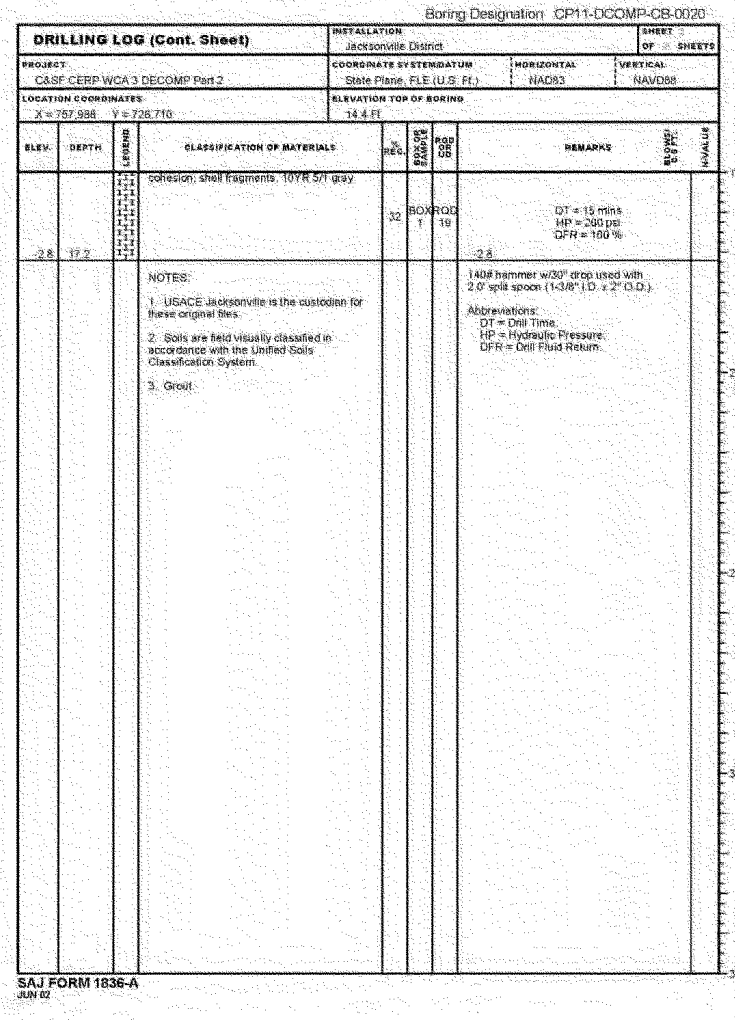
Boring Designation CP11-DCOMP-CB-0020

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
1. PROJECT: C&SF CERP WCA 3 DECOMP Part 2 L-5 South		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP11-DCOMP-CB-0020	LOCATION COORDINATES: X = 757,968 Y = 726,710	11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAJ	CONTRACTOR FILE NO.	12. TOTAL SAMPLES: DISTURBED 0	UNDISTURBED (UD) 0
4. NAME OF DRILLER: Charlie Brown		13. TOTAL NUMBER CORE BOXES: 1	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: Not Encountered
			15. DATE BORING: STARTED 03-17-11 / COMPLETED 03-17-11
6. THICKNESS OF OVERBURDEN: N/A			16. ELEVATION TOP OF BORING: 14.4 Ft.
7. DEPTH DRILLED INTO ROCK: N/A			17. TOTAL RECOVERY FOR BORING: 57 %
8. TOTAL DEPTH OF BORING: 17.2 Ft.			18. SIGNATURE AND TITLE OF INSPECTOR: Michael Fitzharris, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	ROCK CORE SAMPLE	ROCK RQD	REMARKS	BLOWS PER 0.5 FT.	N-VALUE
14.4	0.0						14.4		
13.8	0.6		FILL, sandy, some gravel, trace clay, shell fragments, 5Y 7/1 light gray	83			SPT Sampler 13.8	27 30/0.1	
12.0	2.4		LIMESTONE, moderately hard, weathered, vuggy, 10YR 6/1 gray	44	BOX 1	ROD 19	DT = 5 mins HP = 200 psi DFR = 100 % 12.0		
10.5	3.9		SAND, silty, some gravel, little clay, 5Y 7/1 light gray (SM)	73			SPT Sampler 10.5	24 24 23	47
9.0	5.4			63			SPT Sampler 9.0	17 30 19	49
8.7	5.7		CLAY, organic-H, moist, trace clay, 5Y 2.5/1 black (OH)	33			SPT Sampler 7.5	6 2 2	4
7.1	7.3		SAND, silty, 5Y 5/2 olive gray (SM)	60			SPT Sampler 6.0	2 12 20	32
				53			SPT Sampler 4.5	14 4 3	7
				67			SPT Sampler 3.0	8 6 18	24
				47			SPT Sampler 1.5	43 32 7	39
0.0	14.4			73			SPT Sampler 0.0	2 5 38	43
			LIMESTONE, fossiliferous, moderately hard, vuggy, some gravel, trace clay, low	32	BOX 1	ROD 19			

SAJ FORM 1836
JUN 02

(Continued)



Boring Designation: CP11-DCOMP-CB-0020

DRILLING LOG (Cont. Sheet)

INSTALLATION: Jacksonville District

SHEET: OF SHEETS

PROJECT: C&SF CERP WCA 3 DECOMP Part 2

COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) | HORIZONTAL: NAD83 | VERTICAL: NAVD88

LOCATION COORDINATES: X = 757,988 Y = 728,710

ELEVATION TOP OF BORING: 14.4 Ft

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	RQD	REMARKS	BLOWS PER 6 INCHES	HAND VANE
2.8	17.2		cohesion; shell fragments, 10YR 5/1 gray	32	BOX 1	RQD 19	DT = 15 mins HP = 280 psi DFR = 100 % 2.8		

NOTES:

1. USACE Jacksonville is the custodian for these original files.
2. Soils are field visually classified in accordance with the Unified Soils Classification System.
3. Grout.

140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.).

Abbreviations:
DT = Drill Time.
HP = Hydraulic Pressure.
DFR = Drill Fluid Return.

SAJ FORM 1836-A
JUN 02

Boring Designation: CP11-DCOMP-CB-0022

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
1. PROJECT: C&SF CERP WCA 3 DECOMP Part 2 L-5 South		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. FT.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP11-DCOMP-CB-0022	LOCATION COORDINATES: X = 754,072 Y = 726,667	11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAM	CONTRACTOR FILE NO.	12. TOTAL SAMPLES: 0	DISTURBED: 0 / UNDISTURBED (UD): 0
4. NAME OF DRILLER: Charlie Brown		13. TOTAL NUMBER CORE BOXES: 1	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL:	BEARING:	14. ELEVATION GROUND WATER: Not Encountered
		15. DATE BORING:	STARTED: 03-17-11 / COMPLETED: 03-17-11
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 14.3 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: 71 %	
8. TOTAL DEPTH OF BORING: 15.3 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Michael Fitzharris, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD OR UD	REMARKS	BLOWS / 6 IN.	RUN/LOSS	METERS
14.3	0.0						14.3			0
			FILL: sandy, trace clay, some gravel, trace shells, 10YR 6/1 gray	80			SPT Sampler	17 / 40 / 24	64	
							12.8			
				60			SPT Sampler	16 / 20 / 18	38	
			At El. 11.3 Ft., low plasticity				11.3			
10.7	3.6			50			10.7 SPT Sampler	17 / 50/0.1		
			LIMESTONE, fossiliferous, weathered, vuggy, some clay infills, some oxidation staining, 2.5Y 6/1 gray	29	BOX 1	RQD 0	4 x 5-1/2" DT = 18 mins HP = 200 psi DFR = 100 %			5
6.5	7.8						6.5			
			CLAY, organic-H, some fibrous plant material, 5Y 2.5/1 black, (OH)	100			SPT Sampler	1 / 1 / 1	2	
							5.0			
				93			SPT Sampler	1 / 1 / 1	2	10
3.5	10.8						3.5			
			LIMESTONE, fossiliferous, highly weathered, moderately fractured, fractured between 11.4 to 12.0 ft depth, 10YR 7/2 light gray	82	BOX 1	RQD 51	DT = 18 mins HP = 200 psi DFR = 50 %			
										15

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation CP11-DCOMP-CB-0022

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
PROJECT: C&SF CERP WCA 3 DECOMP Part 2	COORDINATE SYSTEM/DATUM: State Plane FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 754,072 Y = 726,667	ELEVATION TOP OF BORING: 14.3 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	CORE RUN	REMARKS	BLOWS/6 IN. OR RQD	N-VALUE
-1.0	15.3		At El. -0.7 Ft, weak cementation	82			-1.0		

NOTES:

1. USACE Jacksonville is the custodian for these original files.

2. Soils are field visually classified in accordance with the Unified Soils Classification System.

3. Grout

140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.).

Abbreviations:
DT = Drill Time.
HP = Hydraulic Pressure.
DFR = Drill Fluid Return.

15 20 25 30 35

SAJ FORM 1836-A
JUN 92

Boring Designation: CP11-DCOMP-CB-0024

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
1. PROJECT: C&SF CERP WCA 3 DECOMP Part 2 L-3 South		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. FT.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP11-DCOMP-CB-0024	LOCATION COORDINATES: X = 750,077 Y = 726,617	11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAM	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED: 1 / UNDISTURBED (UD): 0
4. NAME OF DRILLER: Charlie Brown		13. TOTAL NUMBER CORE BOXES: 1	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: 12.4 Ft
		15. DATE BORING	STARTED: 03-16-11 / COMPLETED: 03-17-11
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 14.3 Ft	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: 67 %	
8. TOTAL DEPTH OF BORING: 9.7 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Michael Fitzharris, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	RQD OR CORE NO.	REMARKS	BLOWS/ 0.5 FT.	RANGE
14.3	0.0						14.3		
			FILL, gravelly, some sand, strong HCL reaction, 5Y 7/1 light gray	67			SPT Sampler	26 50	0
							12.8		
							Advanced Boring		
11.3	3.0						11.3		
10.8	3.5		SAND, silty, strong reaction with HCL, 2.5Y 7/1 light gray (SM)	75			10.8 SPT Sampler	50	
			LIMESTONE, moderately hard, vuggy, 2.5Y 8/4 pale yellow						5
8.8	5.5								
			CLAY, organic-H, some calcareous sand and gravel, 2.5Y 2.5/1 black (OH)	48	1 BOX 1	RQD 20	4 x 5-1/2" DT = 11 mins HP = 200 psi DFR = 70 %		
5.9	8.4						5.8		
			LIMESTONE, 2.5Y 7/2 light gray	80		RQD 28	4 x 5-1/2" DT = 8 mins HP = 200 psi DFR = 100 %		
4.6	9.7						4.6		
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Grout.				140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.). Abbreviations: DT = Drill Time. HP = Hydraulic Pressure. DFR = Drill Fluid Return.		10 15

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Boring Designation: CP11-DCOMP-CB-0026

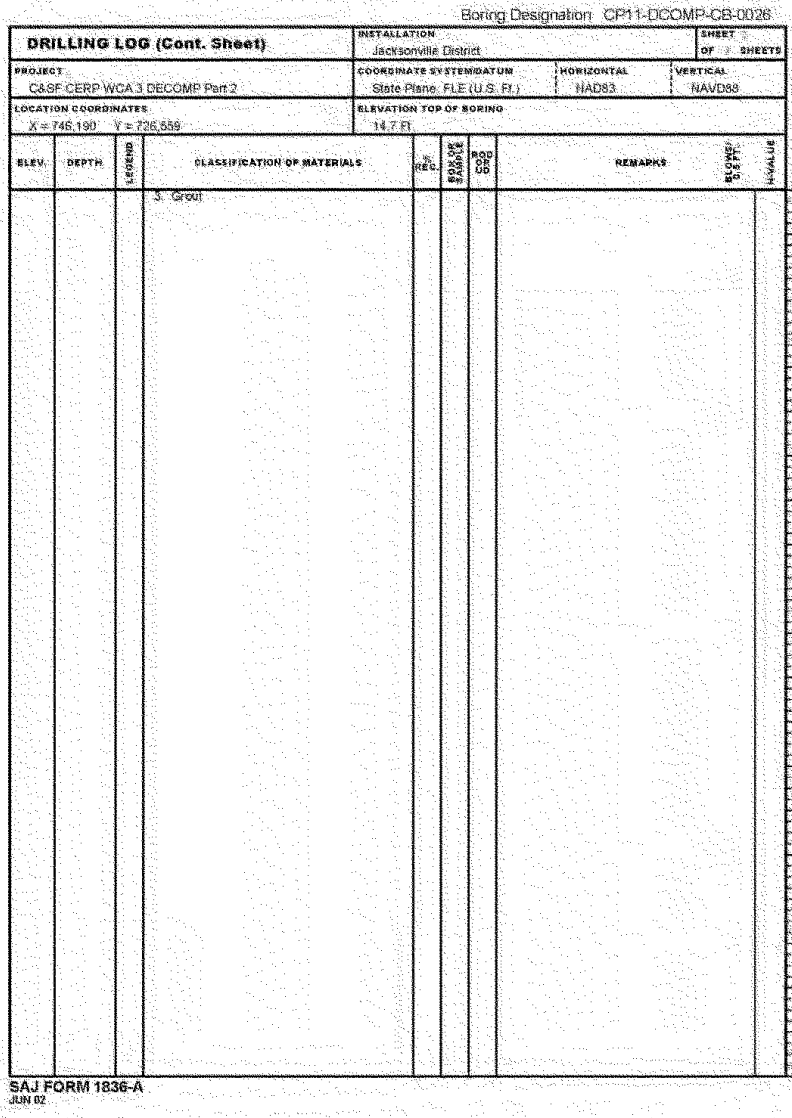
DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District
	SHEET: OF SHEETS
1. PROJECT: C&SF CERP WCA 3 DECOMP Part 2 L-5 South	9. SIZE AND TYPE OF BIT: See Remarks
	10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP11-DCOMP-CB-0026 / LOCATION COORDINATES: X = 748,190 Y = 728,559	11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500 / ☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAM / CONTRACTOR FILE NO.	12. TOTAL SAMPLES: 1 / DISTURBED: 1 / UNDISTURBED (UD): 0
4. NAME OF DRILLER: Charlie Brown	13. TOTAL NUMBER CORE BOXES: 1
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED / DEG. FROM VERTICAL / BEARING	14. ELEVATION GROUND WATER: 7.6 Ft.
	15. DATE BORING: STARTED: 03-19-11 / COMPLETED: 03-19-11
6. THICKNESS OF OVERBURDEN: N/A	16. ELEVATION TOP OF BORING: 14.7 Ft.
7. DEPTH DRILLED INTO ROCK: N/A	17. TOTAL RECOVERY FOR BORING: 74 %
8. TOTAL DEPTH OF BORING: 12.2 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: Michael Fitzhams, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR CORE SIZE	ROD OR CORE	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
14.7	0.0						14.7		
			FILL: sandy, trace gravel; trace shell fragments, some gravel, 5Y 4/1 dark gray	80			SPT Sampler	8 16 19	35
				67			SPT Sampler	11 24 24	48
				75			SPT Sampler	21 50	
				60			SPT Sampler	11 5 3	8
8.7	6.0						8.7		
			CLAY, organic-H, some fibrous material; trace calcareous gravel, 2.5Y 2.5/1 black (OH)	53			SPT Sampler	1 1 7	8
7.2	7.5						7.2		
			SAND, silty, some clay, some organics, little gravel, little shell fragments, 2.5Y 3/1 very dark gray (SM)	63			SPT Sampler	3 50	
5.7	9.0						5.7		
			LIMESTONE, fossiliferous, moderately hard, vuggy, 7.5YR 5/1 gray At El. 5.4 Ft., moderately fractured At El. 4.4 Ft., highly fractured	100	BOX	ROD 53	4 x 5-1/2" DT = 19 mins HP = 200 psi DFR = 90 %		
2.5	12.2						2.5		
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System.				140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.) Abbreviations: DT = Drill Time HP = Hydraulic Pressure DFR = Drill Fluid Return		

SAJ FORM 1836
JUN 02

(Continued)



Boring Designation: CP11-DCOMP-CB-0026

DRILLING LOG (Cont. Sheet)

INSTALLATION	SHEET
Jacksonville District	OF SHEETS

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
C&SF CERP WCA 3 DECOMP Part 2	State Plane, FLE (U.S. Ft.)	NAD83	NAVD88

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 746,190 Y = 726,559	14.7 Ft

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	NO. REC.	BLOWS PER 6"	ROD COR OD	REMARKS	BLOWS PER FT.	WATER
			3. Grout						

15
20
25
30
35

SAJ FORM 1836-A
JUN 02

Boring Designation CP11-DCOMP-CB-0028

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
1. PROJECT: C&SF CERP WCA 3 DECOMP Part 2 L-3 South		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP11-DCOMP-CB-0028	LOCATION COORDINATES: X = 742,303 Y = 726,513	11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAM	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED: 1 / UNDISTURBED (UD): 0
4. NAME OF DRILLER: Charlie Brown		13. TOTAL NUMBER CORE BOXES: 1	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: Not Encountered
			15. DATE BORING: STARTED 03-21-11 / COMPLETED 03-21-11
6. THICKNESS OF OVERBURDEN: N/A			16. ELEVATION TOP OF BORING: 14.5 Ft.
7. DEPTH DRILLED INTO ROCK: N/A			17. TOTAL RECOVERY FOR BORING: 54 %
8. TOTAL DEPTH OF BORING: 12.6 Ft.			18. SIGNATURE AND TITLE OF INSPECTOR: Michael Fitzharris, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR RUN SIZE	RQD OR CSD	REMARKS	BLOWS/0.5 FT.	HP/VALUE
14.5	0.0						14.5		
			FILL, gravelly, 10YR 7/2 light gray	40			SPT Sampler	18 20 14	34
				60			SPT Sampler	12 13 14	27
11.3	3.2		At El. 11.6 Ft., trace organics; trace clay	100			11.5 11.3 SPT Sampler	50/0.2"	
			LIMESTONE, moderately hard, very wide aperture, vuggy, 7.5YR 5/1 gray	80	BOX 1	ROD 0	4 x 5-1/2" DT = 5 mins HP = 200 psi DFR = 80 %		
8.8	5.7						9.3 8.8 Advanced Boring		
			CLAY, organic H, some calcareous gravel, trace clay, 10YR 2/2 very dark brown, (OH)	47			SPT Sampler	4 2 2	4
7.3	7.2						7.3		
			LIMESTONE, intensely weathered, some organics and fibrous material, 2.5YR 5/2 weak red	43			SPT Sampler	6 23 50/0.4"	73+
			At El. 5.9 Ft., fossiliferous, firm, vuggy, some clay infilling, 7.5YR 5/1 gray				5.9		
				63	BOX 1	ROD 44	4 x 5-1/2" DT = 15 mins HP = 200 psi DFR = 100 %		
1.9	12.6						1.9		
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils				140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.). Abbreviations: DT = Drill Time HP = Hydraulic Pressure DFR = Drill Fluid Return		

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(Continued)

Boring Designation CP11-DCOMP-CB-0028

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 2 OF 2 SHEETS
PROJECT: C&SF CERP WCA 3 DECOMP Part 2	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 742,303 Y = 726,513	ELEVATION TOP OF BORING: 14.5 Ft	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD LOSS	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			Classification System:						
			3: Grout						

SAJ FORM 1836-A
JUN 02

Boring Designation CP11-DCOMP-CB-0030

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
1. PROJECT: C&SF CERP WCA 3 DECOMP Part 2 L-5 South		9. SIZE AND TYPE OF B.I.T.: See Remarks	
2. BORING DESIGNATION: CP11-DCOMP-CB-0030	LOCATION COORDINATES: X = 738,282 Y = 726,448	10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 VERTICAL: NAVD88
3. DRILLING AGENCY: Corps of Engineers - CESAM	CONTRACTOR FILE NO.	11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500	☐ AUTO HAMMER ☒ MANUAL HAMMER
4. NAME OF DRILLER: Charlie Brown		12. TOTAL SAMPLES: DISTURBED 1	UNDISTURBED (UD) 0
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL: BEARING:	13. TOTAL NUMBER CORE BOXES: 1	
6. THICKNESS OF OVERBURDEN: N/A		14. ELEVATION GROUND WATER: 5.9 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		15. DATE BORING: STARTED 03-21-11	COMPLETED 03-21-11
8. TOTAL DEPTH OF BORING: 14.0 Ft.		16. ELEVATION TOP OF BORING: 14.1 Ft.	
		17. TOTAL RECOVERY FOR BORING: 79 %	
		18. SIGNATURE AND TITLE OF INSPECTOR: Michael Fitzharris, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC	MAX. OF RUN SAMPLE	ROD % REC	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
14.1	0.0						14.1		
			FILL, sandy, some silt, trace clay, trace organics, trace shells	50			SPT Sampler	7 28 44	72
				60			12.6 SPT Sampler	7 16 34	50
				100			11.1 SPT Sampler	50	
9.2	4.9		CLAY, organic-ft, moist, some fibrous material (OH)	57			9.6 SPT Sampler	5 3 2	5
8.9	5.2			100			SPT Sampler	1 2 4	6
8.6	5.5		CLAY, fat, trace organics (CH)				8.6		
5.3	8.8		CLAY, organic-ft, low plasticity, some clay, some gravel, little sand (OH)	69			SPT Sampler 5.3	5 20 50/0.3	70+
0.1	14.0		LIMESTONE, moderately hard, vuggy, some sandy clay infills	90	BOX 1	ROD 65	4 x 5-1/2" DT = 15 mins HP = 200 psi DFR = 50 %		
			NOTES:				0.1 140# hammer w/30" drop used with 2.0' split spoon (1-3/8" I.D. x 2" O.D.)		

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation CP11-DCOMP-CB-0030

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
PROJECT: C&SF CERP WCA 3 DECOMP Part 2	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 738,282 Y = 726,446	ELEVATION TOP OF BORING: 14.1 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR CORE SAMPLE NO.	RQD OR CORE	REMARKS	BLOWS/6 IN. OR RQD	N-VALUE
			1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Grout.				Abbreviations: DT = Drill Time HP = Hydraulic Pressure DFR = Drill Fluid Return		

SAJ FORM 1836-A
JUN 02

Boring Designation CP11-DCOMP-CB-0032

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District
SHEET: OF SHEETS	
1. PROJECT: C&SF CERP WCA 3 DECOMP Part 2 L-5 South	9. SIZE AND TYPE OF BIT: See Remarks
2. BORING DESIGNATION: CP11-DCOMP-CB-0032	LOCATION COORDINATES: X = 734,280 Y = 726,400
10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 VERTICAL: NAVD88
3. DRILLING AGENCY: Corps of Engineers - CESAJ	CONTRACTOR FILE NO.
11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500	☐ AUTO HAMMER ☒ MANUAL HAMMER
12. TOTAL SAMPLES	DISTURBED: 0 UNDISTURBED (UD): 0
4. NAME OF DRILLER: Charlie Brown	13. TOTAL NUMBER CORE BOXES: 1
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL: BEARING:
14. ELEVATION GROUND WATER: 7.7 Ft.	
15. DATE BORING	STARTED: 03-21-11 COMPLETED: 03-21-11
6. THICKNESS OF OVERBURDEN: N/A	16. ELEVATION TOP OF BORING: 14.9 Ft.
7. DEPTH DRILLED INTO ROCK: N/A	17. TOTAL RECOVERY FOR BORING: 73 %
8. TOTAL DEPTH OF BORING: 25.5 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: Michael Fitzharris, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BLOWS/0.5 FT. OR RQD	ROD OR CORE	REMARKS	BLOWS/0.5 FT.	N VALUE
14.9	0.0						14.9		
			FILL, gravelly, trace organics, 7.5YR 7/1 light gray	73			SPT Sampler	12 42 25	67
			From El. 13.4 to 8.3 Ft., sandy, little gravel, trace organics, 10YR 8/2 light brownish gray	80			SPT Sampler	5 7 8	15
				90			SPT Sampler	9 7 6	13
				33			SPT Sampler	4 2 3	5
8.8	6.3			93			SPT Sampler	1 1 4	5
7.4	7.5		CLAY, organic-H, medium plasticity, some fibrous material, 5Y 2.5/1 black (OH)	53			SPT Sampler	4 2 8	10
5.9	9.0		SAND, clayey, wet, 10YR 5/3 gray (SC)	60			SPT Sampler	4 5 9	14
			SAND, silty, wet, trace gravel, organic odor, 10YR 3/2 very dark grayish brown (SM)	67			SPT Sampler	8 8 7	15
				73			SPT Sampler	5 5 8	13
				80			SPT Sampler	6 6 7	13

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(Continued)

Boring Designation: CP11-DCOMP-CB-0032

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
PROJECT: C&SF CERP WCA 3 DECOMP Part 2	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 734,280 Y = 726,400	ELEVATION TOP OF BORING: 14.9 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
				63			SPT Sampler -1.1	3 / 5 / 7/0.0"	12+
				53			SPT Sampler -3.1	4 / 4 / 4	8
-3.1	18.0		SAND, poorly graded with silt, some shell fragments, organic odor, 2.5Y 6/2 light brownish gray (SP-SM)	67			SPT Sampler -4.6	5 / 8 / 9	17
-4.6	19.5		SAND, silty, some shell fragments, organic odor, 10YR 7/1 light gray (SM)	67			SPT Sampler -6.1	8 / 10 / 7	17
				63			SPT Sampler -7.6	6 / 4 / 3	7
				27			SPT Sampler -9.1	3 / 3 / 7	10
-10.6	25.5			20			SPT Sampler -10.6	2 / 3 / 4	7
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System 3. Grout				140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.)		

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JUN 62

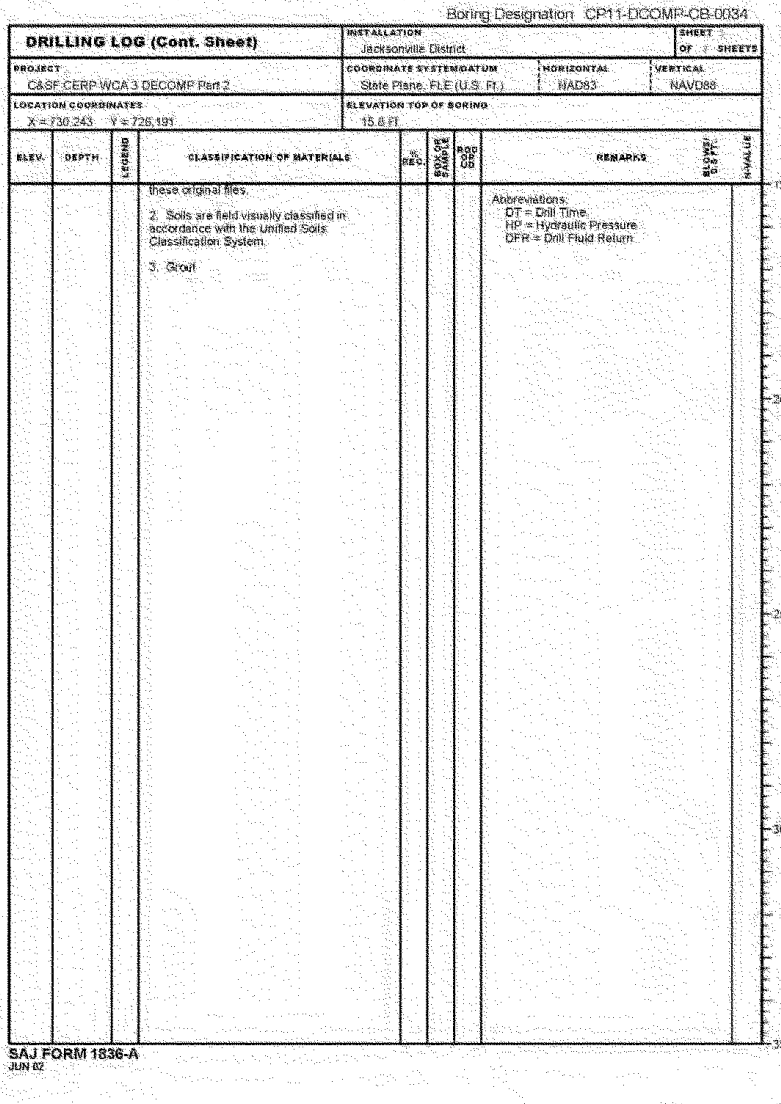
Boring Designation: CP11-DCOMP-CB-0034

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
1. PROJECT: C&SF CERP WCA 3 DECOMP Part 2 S-8 Area, Proposed Pump Station		9. SIZE AND TYPE OF BIT: See Remarks 10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
2. BORING DESIGNATION: CP11-DCOMP-CB-0034 / LOCATION COORDINATES: X = 730,243 Y = 726,191		11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500 ☐ AUTO HAMMER ☒ MANUAL HAMMER	
3. DRILLING AGENCY: Corps of Engineers - CESAM / CONTRACTOR FILE NO.		12. TOTAL SAMPLES: 1 / DISTURBED: 1 / UNDISTURBED (UD): 0	
4. NAME OF DRILLER: Charlie Brown		13. TOTAL NUMBER CORE BOXES: 1	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED / DEG. FROM VERTICAL / BEARING		14. ELEVATION GROUND WATER: 8.5 Ft.	
6. THICKNESS OF OVERBURDEN: N/A		15. DATE BORING: STARTED 03-16-11 / COMPLETED 03-16-11	
7. DEPTH DRILLED INTO ROCK: N/A		16. ELEVATION TOP OF BORING: 15.8 Ft.	
8. TOTAL DEPTH OF BORING: 13.8 Ft.		17. TOTAL RECOVERY FOR BORING: 76 %	
		18. SIGNATURE AND TITLE OF INSPECTOR: Michael Fitzharris, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	NO. REC.	BOX OR GRAB	ROD OR CD	REMARKS	BLOWS PER 6"	BLOWS/FT.
15.8	0.0						15.8		
			SAND, silty, trace coarse grain sand and fine gravel; trace organics and roots in top 6 inches, 2.5Y 4/1 dark gray (SM)	73			SPT Sampler	4 16 26	42
							14.3		
				60			SPT Sampler	2 10 17	27
							12.8		
				93			SPT Sampler	14 14 47	61
11.3	4.5						11.3		
			CLAY, organic-H, strong reaction with HCl, 2.5Y 2.5/1 black (OH)	75			SPT Sampler	3 3 1	4
			From El. 9.9 to 8.3 Ft., trace calcareous gravel						
				80			SPT Sampler	2 2 3	5
8.3	7.5						8.3		
			SAND, silty, some gravel, 5Y 5/1 gray (SM)	53			SPT Sampler	3 9 50	59
6.8	9.0						6.8		
			LIMESTONE, fossiliferous, moderately weathered, soft sandy pockets; vuggy, 10YR 7/1 light gray	90	BOX	ROD 1.77	DT = 11 mins HP = 200 psi DFR = 100 %		
2.0	13.8						2.0		
			NOTES: 1. USACE Jacksonville is the custodian for				140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.)		

SAJ FORM 1836
JUN 02

(Continued)



Boring Designation CP11-DCOMP-CB-0034

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 2 OF 2 SHEETS
PROJECT: C&SF CERP WCA 3 DECOMP Part 2	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 730,243 Y = 726,191	ELEVATION TOP OF BORING: 15.8 Ft	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BLOCK OR SAMPLE NO.	ROD OR CORE	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Grout				Abbreviations: DT = Drill Time HP = Hydraulic Pressure DFR = Drill Fluid Return		

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SAJ FORM 1836-A
JUN 02

Boring Designation CP11-DCOMP-CB-0035

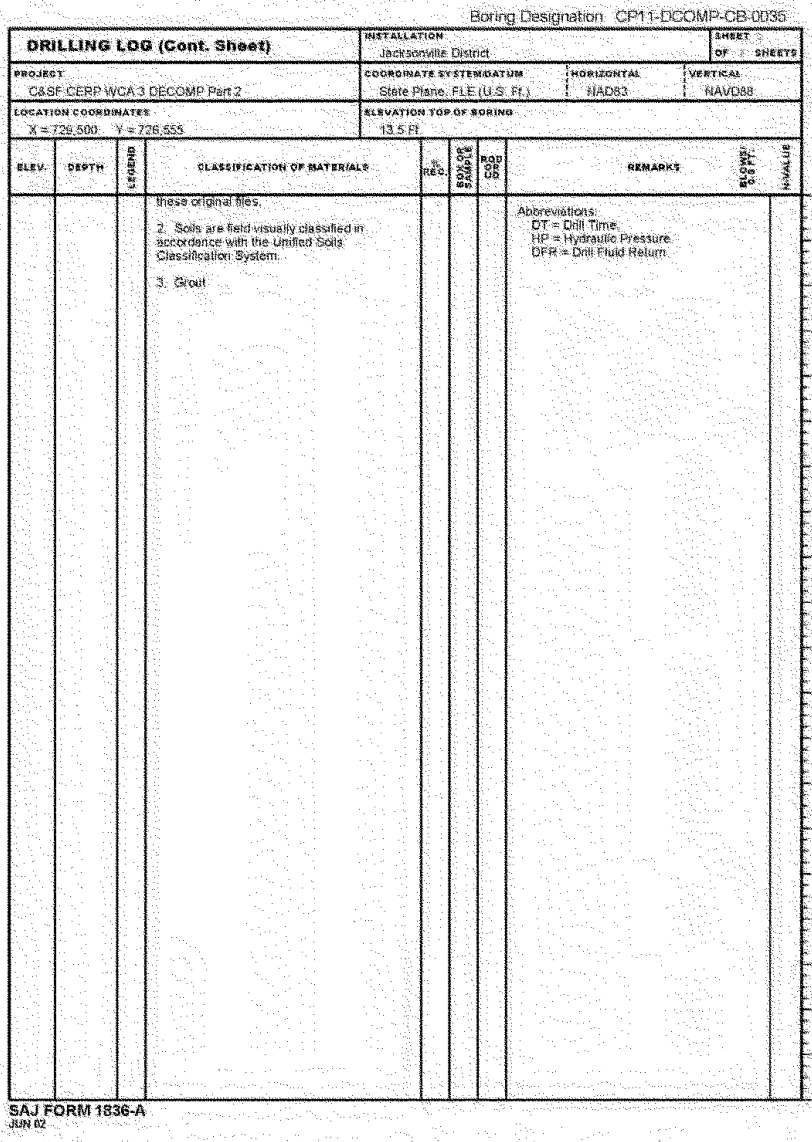
DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District		SHEET: OF SHEETS
1. PROJECT: C&SF CERP WCA 3 DECOMP Part 2 Proposed Pump Station	9. SIZE AND TYPE OF BIT: See Remarks		
	10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83	VERTICAL: NAVD88
2. BORING DESIGNATION: CP11-DCOMP-CB-0035	LOCATION COORDINATES: X = 728,500 Y = 726,555	11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAM	CONTRACTOR FILE NO.	12. TOTAL SAMPLES: 1	DISTURBED: 1 UNDISTURBED (UD): 0
4. NAME OF DRILLER: Charlie Brown		13. TOTAL NUMBER CORE BOXES: 1	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL:	BEARING:	14. ELEVATION GROUND WATER: 9.5 Ft.
		15. DATE BORING:	STARTED: 03-16-11 COMPLETED: 03-16-11
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 13.5 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: 71 %	
8. TOTAL DEPTH OF BORING: 13.8 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Michael Fitzhams, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	RQD OR COC	REMARKS	BLOWS/0.5 FT.	N-VALUE
13.5	0.0						13.5		
			FILL, sandy, nonplastic, trace organics and roots, some coarse grain sand and fine gravel, 10YR 4/1 dark grey	80			SPT Sampler	20 41 16	57
				53			SPT Sampler	20 15 16	31
				75			SPT Sampler	15 10 7	17
8.5	5.0		SAND, silty, wet, some gravel, trace clay, 5Y 7/1 light gray (SM)	93			SPT Sampler	5 7 50	57
				58			SPT Sampler	34 15 50	65
6.0	7.5		LIMESTONE, fossiliferous, slightly weathered, some vugs	92		ROD 50	4 x 5-1/2" DT = 8 mins HP = 200 psi DFR = 60 %		
			At El. 5.2 Ft., slightly fractured	50	BOX 1	ROD 37	4 x 5-1/2" DT = 6 mins HP = 200 psi DFR = 60 %		
-0.3	13.8		NOTES: 1. USACE Jacksonville is the custodian for				-0.3 140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.)		

SAJ FORM 1836
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(Continued)



Boring Designation: CP11-DCOMP-CB-0035

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
PROJECT: C&SF CERP WCA 3 DECOMP Part 2	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 729,500 Y = 726,555	ELEVATION TOP OF BORING: 13.5 Ft	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD OR CORE NO.	REMARKS	BLOWS/ 6 IN.	N-VALUE
			these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Grout				Abbreviations: DT = Drill Time HP = Hydraulic Pressure DFR = Drill Fluid Return		

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SAJ FORM 1836-A
JUN 02

Boring Designation CP11-DCOMP-CB-0036

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF SHEETS
1. PROJECT: C&SF CERP WCA 3 DECOMP Part 2 L-4 North, Proposed Pump Station		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. FL)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP11-DCOMP-CB-0036	LOCATION COORDINATES: X = 710,800 Y = 726,372	11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAM	CONTRACTOR FILE NO.	12. TOTAL SAMPLES: 1	DISTURBED: 1 / UNDISTURBED (US): 0
4. NAME OF DRILLER: Charlie Brown		13. TOTAL NUMBER CORE BOXES: 1	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: 9.0 Ft.
		15. DATE BORING:	STARTED: 03-15-11 / COMPLETED: 03-15-11
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 16.6 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: 69 %	
8. TOTAL DEPTH OF BORING: 22.7 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Michael Fitzharris, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD OR COR NO.	REMARKS	BLOWS/0.5 FT.	N-VALUE
16.6	0.0						16.6		
			FILL, fine grained sand with some fine and coarse grained gravel, trace clay, 2.5YR 6/2 pale red	73			SPT Sampler	8 15 16	31
13.6	3.0			80			13.6 SPT Sampler	4 7 9	16
			SAND, clayey, some fine gravel, trace silt, 5Y 4/1 dark grey (SC)	80			SPT Sampler	5 5 3	8
10.6	6.0			73			12.1 SPT Sampler	3 3 5	8
9.1	7.5		CLAY, organic L, moist, organic soil with calcareous sand and gravel particles, 5Y 2.5/1 black (OL)	87			10.6 SPT Sampler	2 1 1	2
7.1	9.5		SAND, clayey, moist, calcareous sand and gravel fragments, 7.5YR 2.5/1 black (SC)	63			9.1 SPT Sampler	WOH 1 1	2
6.1	10.5		CLAY, lean, moist, some calcareous gravel, little organics, 10YR 4/1 dark grey (CL)	93			7.6 SPT Sampler	2 1 4	5
4.6	12.0		SAND, clayey, trace gravel, trace silt, 2.5Y 6/1 gray (SC)	87			6.1 SPT Sampler	2 2 4	6
3.1	13.5		SAND, silty, some coarse gravel, 2.5Y 6/1 gray (SM)	40			4.6 SPT Sampler	2 4 16	20
			LIMESTONE, fossiliferous, weathered, moderately fractured, vuggy, glaconitic staining; some clay infills, 5Y 8/1 white	65	BOX 1	ROD 32	3.1 4 x 5-1/2" DT = 9 mins HP = 200 psi DFR = 100 %		

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation CP11-DCOMP-CB-0036

DRILLING LOG (Cont. Sheet)	INSTALLATION Jacksonville District	SHEET OF SHEETS
PROJECT CASF CERP WCA 3 DECOMP Part 2	COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.)	HORIZONTAL NAD83 / VERTICAL NAVD88
LOCATION COORDINATES X = 710,880 Y = 726,372	ELEVATION TOP OF BORING 16.6 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX NO. OR CORE NO.	ROD RUN	REMARKS	BLOWS/ 0.5 FT.	HAMMER
				65		ROD 32	4 x 5-1/2" DT = 9 mins HP = 200 psi DFR = 100 %		
							-0.3		
				40	BOX 1 1	ROD 11	4 x 5-1/2" DT = 5 mins HP = 200 psi DFR = 70 %		
-8.1	22.7						-8.1		
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Grout				140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.) Abbreviations: WOH = Weight of Hammer DT = Drill Time HP = Hydraulic Pressure DFR = Drill Fluid Return		

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Boring Designation CP11-DCOMP-CB-0037

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
1. PROJECT: CASP CERP WCA 3 DECOMP Part 2 L-4 South, Proposed Pump Station Alternate		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. FT.)	HORIZONTAL: NAD83 VERTICAL: NAVD88
2. BORING DESIGNATION: CP11-DCOMP-CB-0037	LOCATION COORDINATES: X = 710,839 Y = 726,187	11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAM	CONTRACTOR FILE NO.	12. TOTAL SAMPLES: 1	DISTURBED: 1 UNDISTURBED (UD): 0
4. NAME OF DRILLER: Charlie Brown		13. TOTAL NUMBER CORE BOXES: 1	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: 8.3 Ft.
			15. DATE BORING: STARTED 03-22-11 COMPLETED 03-22-11
6. THICKNESS OF OVERBURDEN: N/A			16. ELEVATION TOP OF BORING: 20.0 Ft.
7. DEPTH DRILLED INTO ROCK: N/A			17. TOTAL RECOVERY FOR BORING: 61 %
8. TOTAL DEPTH OF BORING: 20.7 Ft.			18. SIGNATURE AND TITLE OF INSPECTOR: Michael Fitzhams, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BLOWS OR SAMPLE	ROD OR CORE	REMARKS	BLOWS PER 6 INCHES	N-VALUE	
20.0	0.0						20.0			0
			FILL, gravelly, trace organics, trace clay, trace roots, some shell fragments, 5YR 7/1 light gray	67			SPT Sampler	10 24 16	40	
			From El. 18.5 to 14.0 Ft., sandy, trace organics, trace shell fragments, 7.5YR 4/1 dark gray	53			18.5 SPT Sampler	4 9 5	14	
				87			17.0 SPT Sampler	8 9 10	23	
				87			15.5 SPT Sampler	13 11 15	36	5
			From El. 14.0 to 12.5 Ft., gravelly, some silt, 7.5YR 5/2 brown	87			14.0 SPT Sampler	21 13 10	22	
			From El. 12.5 to 11.0 Ft., sandy, 10YR 5/1 gray	0			12.5 SPT Sampler	12 5 6	12	
11.0	9.0						11.0			
10.9	9.1		SAND, clayey, trace gravel, some shell fragments, 10YR 7/1 light gray (SC)							
10.7	9.3		CLAY, organic-L, low plasticity, some sand, 10YR 2/1 black (OL)	80			SPT Sampler	3 2 2	4	10
10.5	9.5		SAND, silty, some shell fragments, 10YR 7/2 light gray (SM)				9.5 SPT Sampler	1 2 2	4	
			CLAY, organic-H, some fibrous material, 5YR 2.5/2 dark reddish brown (OH)	100			SPT Sampler	WOH WOH WOH	0	
8.0	12.0		SAND, silty, 10YR 2/2 very dark brown (SM)				8.0 SPT Sampler	2 7 7	14	
5.9	14.1			100			6.5			
			SAND, clayey, some gravel and silt, some shell fragments, trace organics, 10YR 5/2 grayish brown (SC)	80			SPT Sampler			15

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation CP11-DCOMP-CB-0037

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
PROJECT: C&SF CERP WCA 3 DECOMP Part 2	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 710,839 Y = 726,167	ELEVATION TOP OF BORING: 20.0 Ft	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD OR CORE RUN	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
				89			SPT Sampler	4 / 4 / 50/0.1"	54+
				0			3.7 Advanced Boring		
1.9	18.1						1.9		
			LIMESTONE: moderately hard, moderately fractured, vuggy, 10YR 7/1 light gray	100	BOX/ROD 1 - 42		4 x 5-1/2" DT = 11 mins HP = 200 psi DFR = 90 %		
-0.7	20.7						0.7		

NOTES:

1. USACE Jacksonville is the custodian for these original files.
2. Soils are field visually classified in accordance with the United Soils Classification System.
3. Grout

140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.)

Abbreviations:
WOH = Weight of Hammer
DT = Drill Time
HP = Hydraulic Pressure
DFR = Drill Fluid Return

SAJ FORM 1836-A
JUN 02

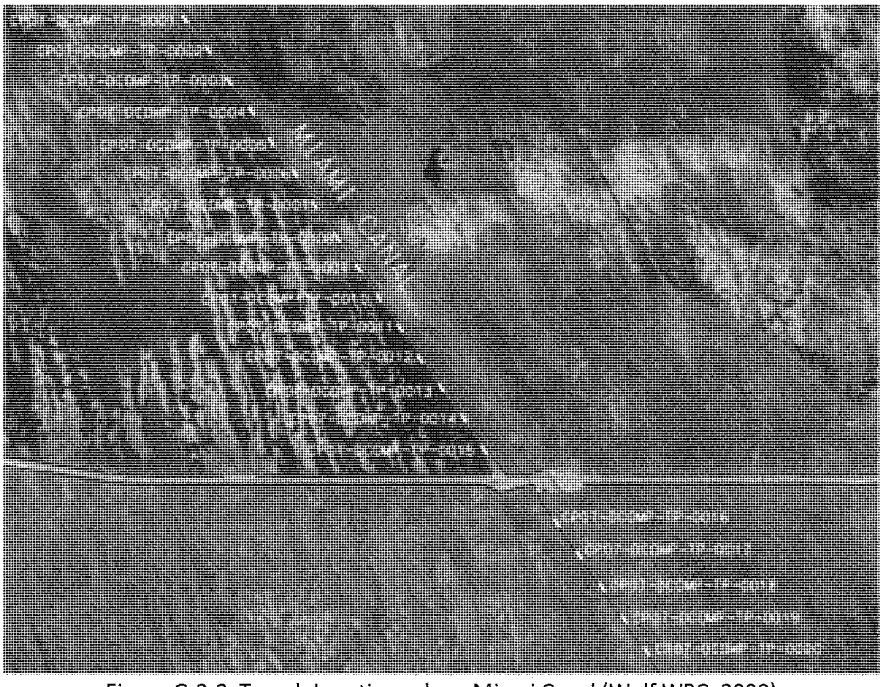
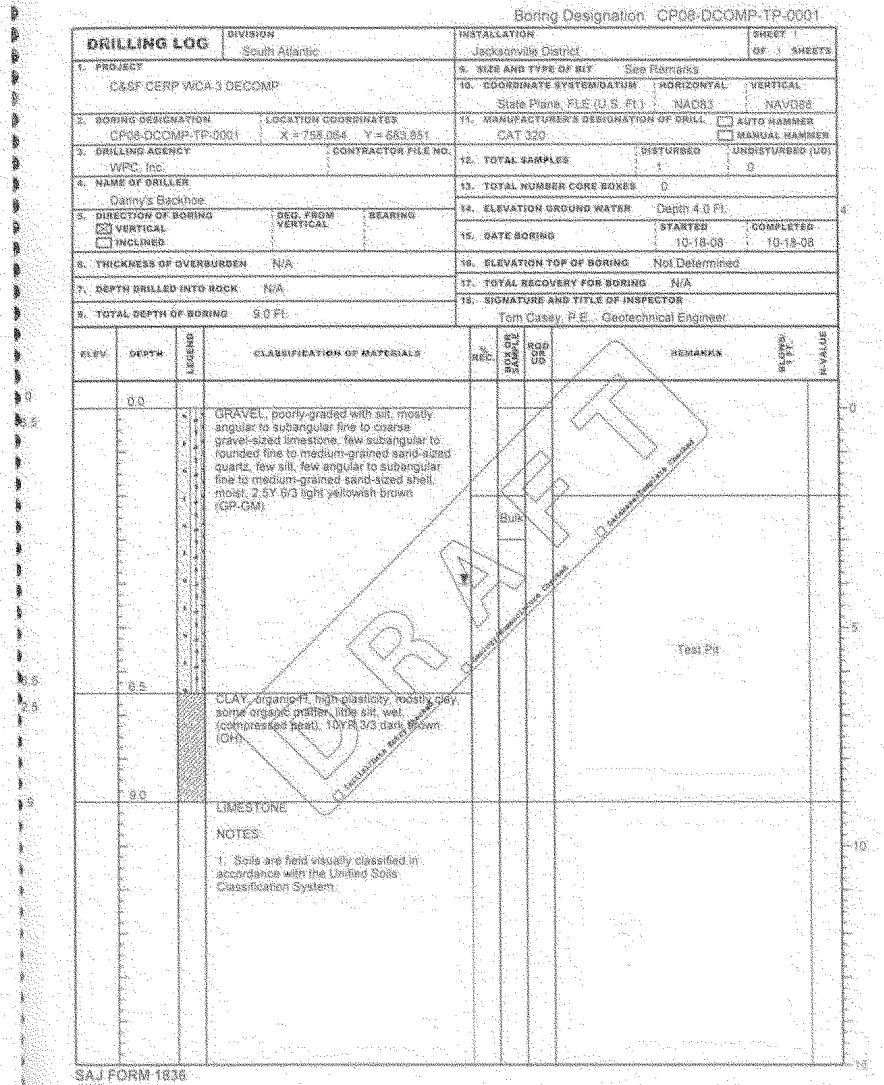


Figure G-2-3. Trench Locations along Miami Canal (Wolf WPC, 2009)



Boring Designation CP08-DCOMP-TP-0001

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District
SHEET 1 OF 1 SHEETS	
1. PROJECT: C&SF CERP WCA 3 DECOMP	9. SIZE AND TYPE OF BIT: See Remarks
10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
2. BORING DESIGNATION: CP08-DCOMP-TP-0001 / LOCATION COORDINATES: X = 758,064 Y = 683,951	11. MANUFACTURER'S DESIGNATION OF DRILL: CAT 320 ☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: WPC, Inc. / CONTRACTOR FILE NO.:	12. TOTAL SAMPLES: DISTURBED 1 / UNDISTURBED (UD) 0
4. NAME OF DRILLER: Danny's Backhoe	13. TOTAL NUMBER CORE BOXES: 0
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED / DEG. FROM VERTICAL / BEARING	14. ELEVATION GROUND WATER: Depth 4.0 Ft.
	15. DATE BORING: STARTED 10-18-08 / COMPLETED 10-18-08
6. THICKNESS OF OVERBURDEN: N/A	16. ELEVATION TOP OF BORING: Not Determined
7. DEPTH DRILLED INTO ROCK: N/A	17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 9.0 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: Tom Casey, P.E., Geotechnical Engineer

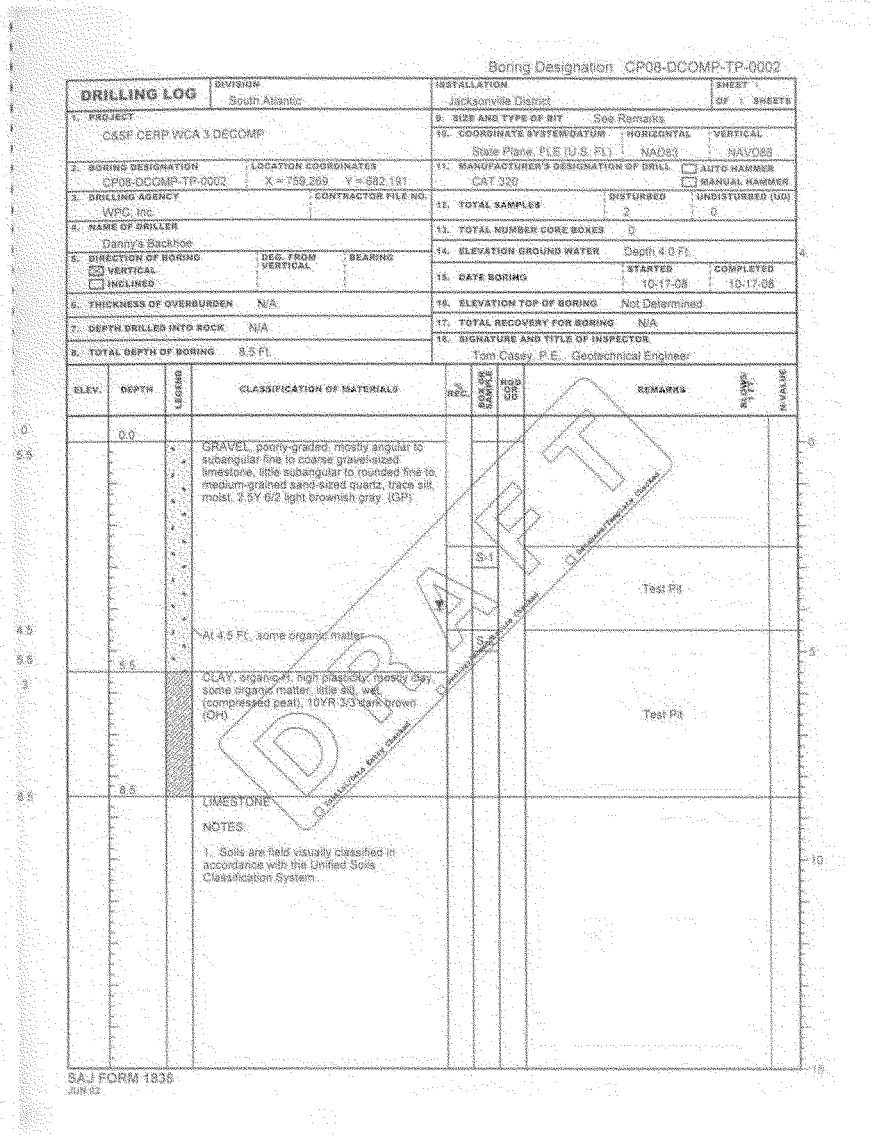
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	TOP OF SAMPLE	ROD DROP	REMARKS	PEN. OR RETR.	N-VALUE
0.0	0.0								
6.5	6.5		GRAVEL, poorly-graded with silt, mostly angular to subangular fine to coarse gravel-sized limestone, few subangular to rounded fine to medium-grained sand-sized quartz, few silt, few angular to subangular fine to medium-grained sand-sized shell, moist, 2.5Y 6/3 light yellowish brown (GP-GM)				Bulk Test Pit		
2.5	9.0		CLAY, organic-fl, high plasticity, mostly clay, some organic matter, little silt, wet, (compressed peat), 10YR 3/3 dark brown (OH)						
-2.5			LIMESTONE						

NOTES:

1. Soils are field visually classified in accordance with the United Soils Classification System.

SAJ FORM 1836
JUN 00

DRAFT



Boring Designation CP08-DCOMP-TP-0002

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District		SHEET 1 OF 1 SHEETS
1. PROJECT: C&SF CERP WCA 3 DECOMP	9. SIZE AND TYPE OF BIT: See Remarks		
	10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83	VERTICAL: NAVD88
2. BORING DESIGNATION: CP08-DCOMP-TP-0002	LOCATION COORDINATES: X = 759,289 Y = 582,191	11. MANUFACTURER'S DESIGNATION OF DRILL: CAT 320	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: WPC, Inc.	CONTRACTOR FILE NO.:	12. TOTAL SAMPLES: 2	DISTURBED: 2 UNDISTURBED (UD): 0
4. NAME OF DRILLER: Danny's Backhoe		13. TOTAL NUMBER CORE BOXES: 0	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL:	BEARING:	14. ELEVATION GROUND WATER: Depth 4.0 Ft.
		15. DATE BORING:	STARTED: 10-17-08 COMPLETED: 10-17-08
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: Not Determined	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: N/A	
8. TOTAL DEPTH OF BORING: 8.5 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Tom Casey, P.E., Geotechnical Engineer	

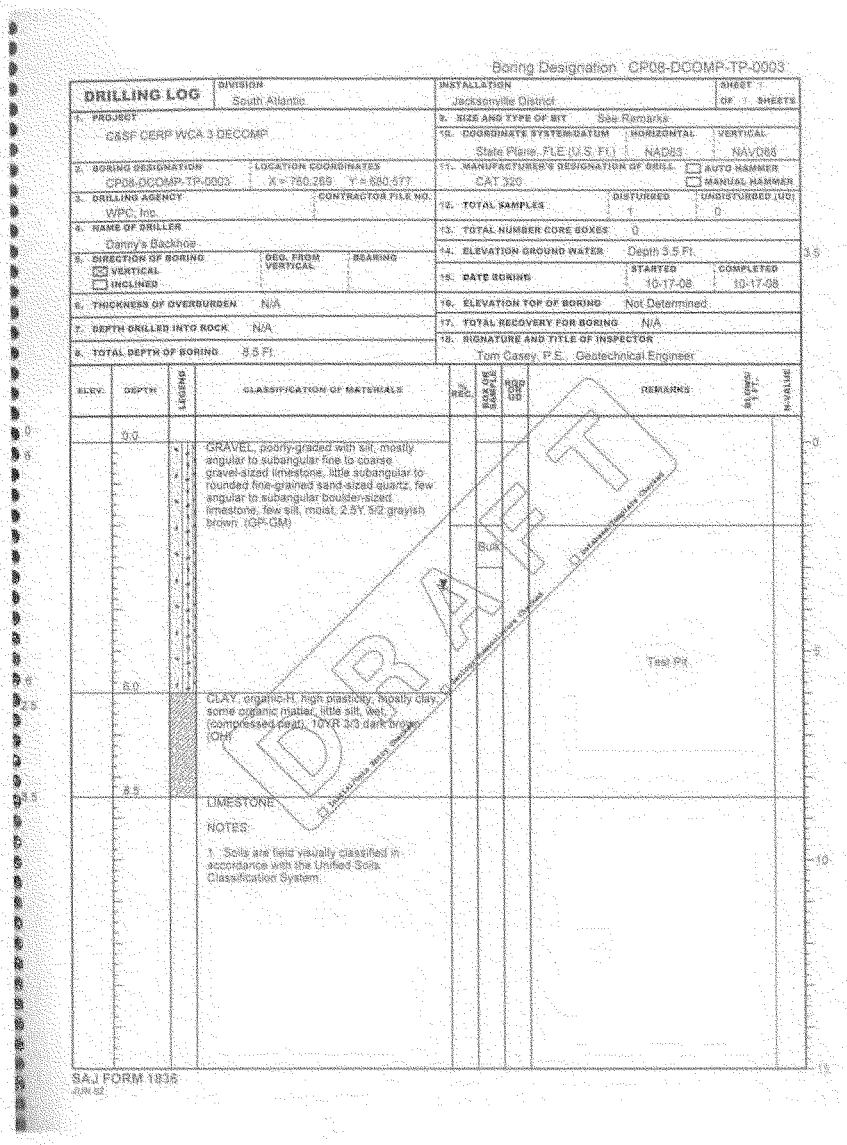
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	SAMPLE NO. OR TYPE	BLOWS/6"	REMARKS	BLOWS/FT.	N-VALUE
0	0.0		GRAVEL, poorly-graded, mostly angular to subangular fine to coarse gravel-sized limestone, little subangular to rounded fine to medium-grained sand-sized quartz, trace silt, moist, 2.5Y 6/2 light brownish gray (GP)						
					S-1		Test Pit		
-4.5	4.5		At 4.5 Ft., some organic matter						
-5.5	5.5				S-2				
-8.5	8.5		CLAY, organic-rich, high plasticity, mostly clay, some organic matter, little silt, wet, (compressed peat), 10YR 3/3 dark brown (OH)				Test Pit		
			LIMESTONE						

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

SAJ FORM 1836
JUN 02

DRAFT



Boring Designation CP08-DCOMP-TP-0003

DRILLING LOG

DIVISION	South Atlantic
INSTALLATION	Jacksonville District
SHEET	1 OF 1 SHEETS
1. PROJECT	CASF CERP WCA 3 DECOMP
2. BORING DESIGNATION	CP08-DCOMP-TP-0003
LOCATION COORDINATES	X = 760,269 Y = 880,577
3. DRILLING AGENCY	WPC, Inc.
CONTRACTOR FILE NO.	
4. NAME OF DRILLER	Danny's Backhoe
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	N/A
7. DEPTH DRILLED INTO ROCK	N/A
8. TOTAL DEPTH OF BORING	8.5 Ft.
9. SIZE AND TYPE OF BIT	See Remarks
10. COORDINATE SYSTEM/DATUM	State Plane, FLE (U.S. Ft.)
HORIZONTAL	NAD83
VERTICAL	NAVD88
11. MANUFACTURER'S DESIGNATION OF DRILL	CAT 320
☐ AUTO HAMMER ☐ MANUAL HAMMER	
12. TOTAL SAMPLES	DISTURBED 1 UNDISTURBED (UC) 0
13. TOTAL NUMBER CORE BOXES	0
14. ELEVATION GROUND WATER	Depth 3.5 Ft.
15. DATE BORING	STARTED 10-17-08 COMPLETED 10-17-08
16. ELEVATION TOP OF BORING	Not Determined
17. TOTAL RECOVERY FOR BORING	N/A
18. SIGNATURE AND TITLE OF INSPECTOR	Tom Casey, P.E., Geotechnical Engineer

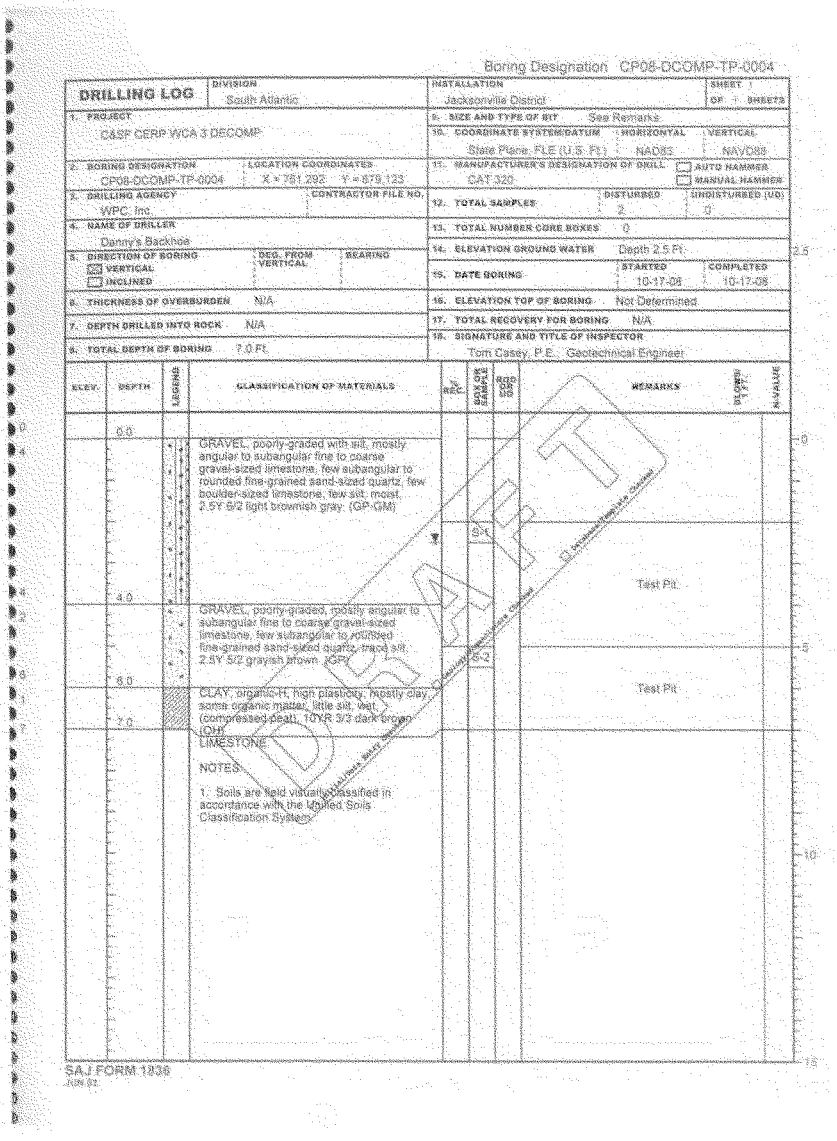
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX OR SAMPLE NO.	ROD OR CORE	REMARKS	BLOWS/6 IN.	N-VALUE
	0.0		GRAVEL, poorly-graded with silt, mostly angular to subangular fine to coarse gravel-sized limestone, little subangular to rounded fine-grained sand-sized quartz, few angular to subangular boulder-sized limestone, few silt, moist, 2.5Y 5/2 grayish brown (GP-GM)		Bulk		Test Pit		
	5.0		CLAY, organic-H, high plasticity, mostly clay, some organic matter, little silt, wet, (compressed peat), 10YR 3/3 dark brown (OH)						
	8.5		LIMESTONE						

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

SAJ FORM 1836
JUN 92

DRAFT



Boring Designation CP08-DCOMP-TP-0004

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District
SHEET 1 OF 1 SHEETS	
1. PROJECT: C&SF CERP WCA 3 DECOMP	9. SIZE AND TYPE OF BIT: See Remarks
	10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP08-DCOMP-TP-0004 / LOCATION COORDINATES: X = 781,292 Y = 879,123	11. MANUFACTURER'S DESIGNATION OF DRILL: CAT 320 / ☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: WPC, Inc. / CONTRACTOR FILE NO.	12. TOTAL SAMPLES: DISTURBED 2 / UNDISTURBED (UD) 0
4. NAME OF DRILLER: Danny's Backhoe	13. TOTAL NUMBER CORE BOXES: 0
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED / DEG. FROM VERTICAL / BEARING	14. ELEVATION GROUND WATER: Depth 2.5 Ft.
	15. DATE BORING: STARTED 10-17-08 / COMPLETED 10-17-08
6. THICKNESS OF OVERBURDEN: N/A	16. ELEVATION TOP OF BORING: Not Determined
7. DEPTH DRILLED INTO ROCK: N/A	17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 7.0 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: Tom Casey, P.E., Geotechnical Engineer

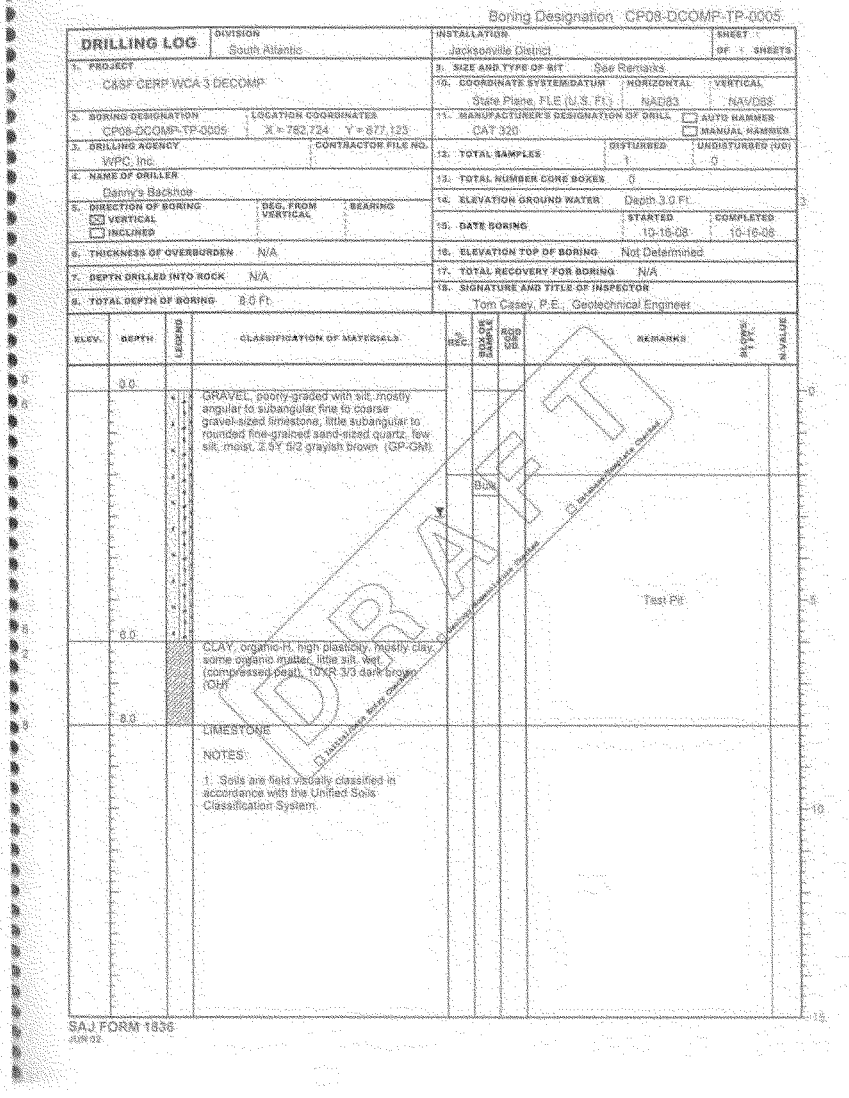
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC. %	BOX OR SAMPLE NO.	RQD %	REMARKS	BLOWS PER FT.	N-VALUE
	0.0		GRAVEL, poorly-graded with silt, mostly angular to subangular fine to coarse gravel-sized limestone, few subangular to rounded fine-grained sand-sized quartz, few boulder-sized limestone, few silt, moist, 2.5Y 5/2 light brownish gray. (GP-GM)		S-1		Test Pit		
	4.0		GRAVEL, poorly-graded, mostly angular to subangular fine to coarse gravel-sized limestone, few subangular to rounded fine-grained sand-sized quartz, trace silt, 2.5Y 5/2 grayish brown. (GP)		S-2		Test Pit		
	6.0		CLAY, organic-H, high plasticity, mostly clay, some organic matter, little silt, wet, (compressed peat), 10YR 3/3 dark brown. (OH)						
	7.0		LIMESTONE						

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

SAJ FORM 1836
JUN 91

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Boring Designation CP08-DCOMP-TP-0005

DRILLING LOG

DIVISION	South Atlantic
INSTALLATION	Jacksonville District
SHEET	OF SHEETS
1. PROJECT	C&SF CERP WCA 3 DECOMP
2. BORING DESIGNATION	CP08-DCOMP-TP-0005
LOCATION COORDINATES	X = 752,724 Y = 877,123
3. DRILLING AGENCY	WPC, Inc.
CONTRACTOR FILE NO.	
4. NAME OF DRILLER	Danny's Backhoe
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	N/A
7. DEPTH DRILLED INTO ROCK	N/A
8. TOTAL DEPTH OF BORING	8.0 Ft.
9. SIZE AND TYPE OF BIT	See Remarks
10. COORDINATE SYSTEM/DATUM	State Plane, FLE (U.S. Ft.)
HORIZONTAL	NAD83
VERTICAL	NAVD88
11. MANUFACTURER'S DESIGNATION OF DRILL	CAT 320
☐ AUTO HAMMER ☐ MANUAL HAMMER	
12. TOTAL SAMPLES	DISTURBED 1 / UNDISTURBED (UD) 0
13. TOTAL NUMBER CORE BOXES	0
14. ELEVATION GROUND WATER	Depth 3.0 Ft.
15. DATE BORING	STARTED 10-16-08 / COMPLETED 10-16-08
16. ELEVATION TOP OF BORING	Not Determined
17. TOTAL RECOVERY FOR BORING	N/A
18. SIGNATURE AND TITLE OF INSPECTOR	Tom Casey, P.E., Geotechnical Engineer

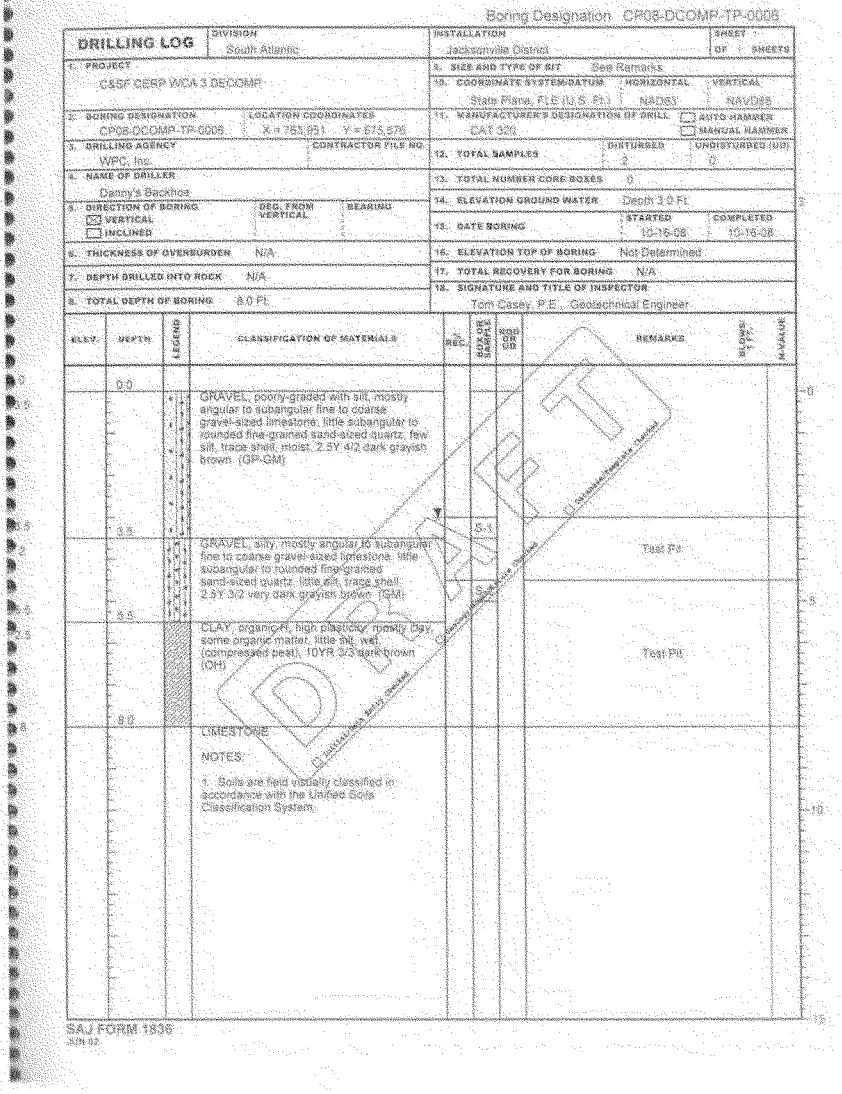
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	CORE RUN	REMARKS	BLOWS PER FT.	N-VALUE
	0.0		GRAVEL, poorly-graded with silt, mostly angular to subangular fine to coarse gravel-sized limestone, little subangular to rounded fine-grained sand-sized quartz, few silt, moist, 2.5Y 5/2 grayish brown (GP-GM)		Bulk		Test Pit		
	6.0		CLAY, organic-H, high plasticity, mostly clay, some organic matter, little silt, wet (compressed peat), 10YR 3/3 dark brown (OH)						
	8.0		LIMESTONE						

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

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SAJ FORM 1836
JUN 02



Boring Designation CP08-DCOMP-TP-0008

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District
1. PROJECT: CSSF CERP WCA 3 DECOMP	9. SIZE AND TYPE OF BIT: See Remarks
2. BORING DESIGNATION: CP08-DCOMP-TP-0008	10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 751,851 Y = 675,575	11. MANUFACTURER'S DESIGNATION OF DRILL: CAT 320 ☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: WPC, Inc. / CONTRACTOR FILE NO.	12. TOTAL SAMPLES: DISTURBED 3 / UNDISTURBED (UD) 0
4. NAME OF DRILLER: Danny's Backhoe	13. TOTAL NUMBER CORE BOXES: 0
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED / DEG. FROM VERTICAL: / BEARING:	14. ELEVATION GROUND WATER: Depth 3.0 Ft
	15. DATE BORING: STARTED 10-16-08 / COMPLETED 10-16-08
6. THICKNESS OF OVERBURDEN: N/A	16. ELEVATION TOP OF BORING: Not Determined
7. DEPTH DRILLED INTO ROCK: N/A	17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 8.0 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: Tom Casey, P.E., Geotechnical Engineer

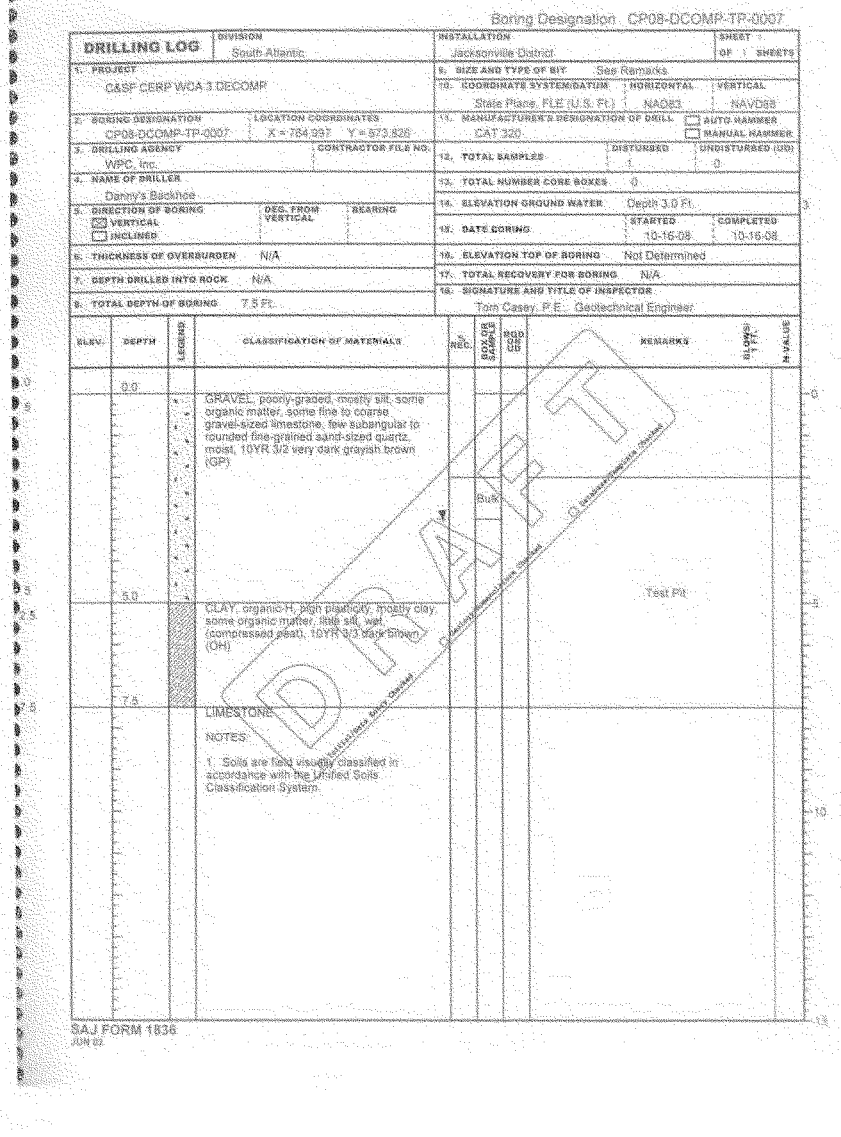
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX OR SAMPLE NO.	CORE RUN	REMARKS	BLOWS/6 IN.	N-VALUE
	0.0		GRAVEL, poorly-graded with silt, mostly angular to subangular fine to coarse gravel-sized limestone, little subangular to rounded fine-grained sand-sized quartz, few silt, trace shell, moist, 2.5Y 4/2 dark grayish brown (GP-GM)						
	3.5		GRAVEL, silty, mostly angular to subangular fine to coarse gravel-sized limestone, little subangular to rounded fine-grained sand-sized quartz, little silt, trace shell, 2.5Y 3/2 very dark grayish brown (GM)		S-1		Test Pit		
	5.5		CLAY, organic-ft, high plasticity, mostly clay, some organic matter, little silt, wet, (compressed peat), 10YR 3/3 dark brown (OH)		S-2		Test Pit		
	8.0		LIMESTONE						

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

SAJ FORM 1836
JUN 92

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Boring Designation CP08-DCOMP-TP-0007

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
1. PROJECT: C&SF CERP WCA 3 DECOMP		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP08-DCOMP-TP-0007	LOCATION COORDINATES: X = 784,997 Y = 573,826	11. MANUFACTURER'S DESIGNATION OF DRILL: CAT 320	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: WPC, Inc.	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED: 1 / UNDISTURBED (UD): 0
4. NAME OF DRILLER: Danny's Backhoe		13. TOTAL NUMBER CORE BOXES: 0	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: Depth 3.0 Ft.
			15. DATE BORING: STARTED 10-16-08 / COMPLETED 10-16-08
6. THICKNESS OF OVERBURDEN: N/A			16. ELEVATION TOP OF BORING: Not Determined
7. DEPTH DRILLED INTO ROCK: N/A			17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 7.5 Ft.			18. SIGNATURE AND TITLE OF INSPECTOR: Tom Casey, P.E. Geotechnical Engineer

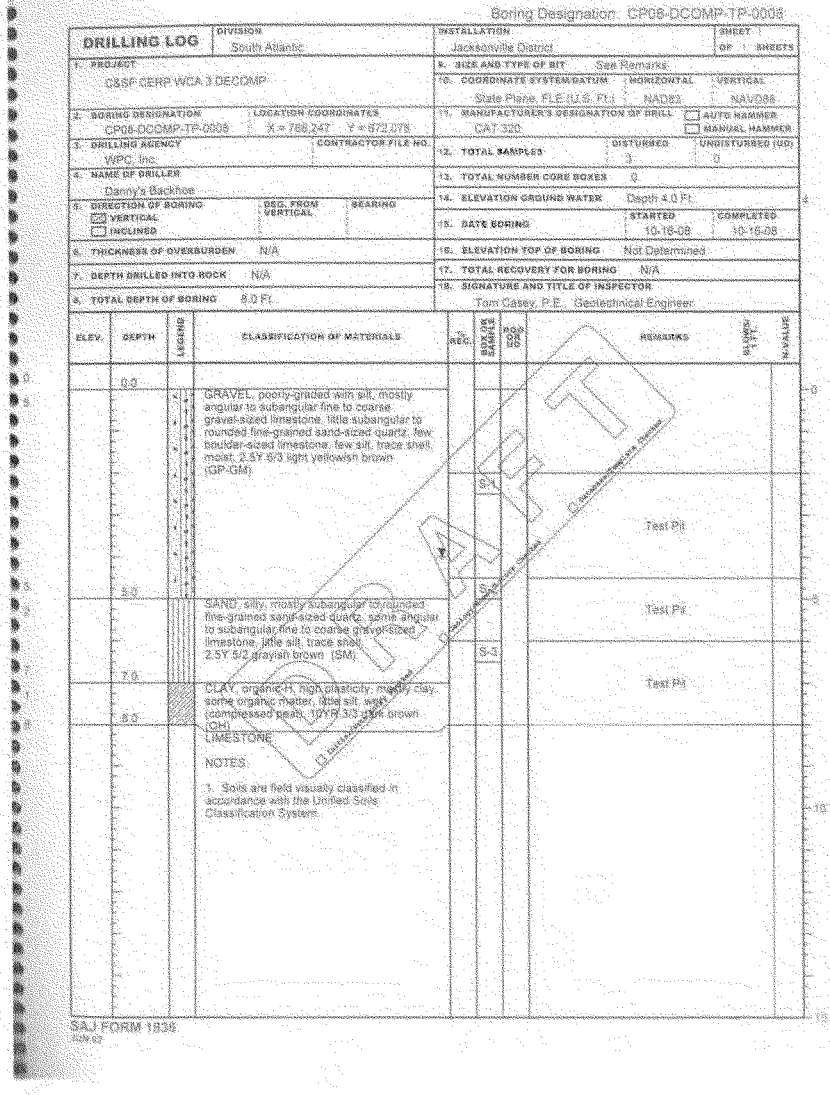
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX OR SAMPLE NO.	RQD DEC.	REMARKS	BLOWS PER FT.	N VALUE
	0.0		GRAVEL, poorly-graded, mostly silt, some organic matter, some fine to coarse gravel-sized limestone, few subangular to rounded fine-grained sand-sized quartz, moist, 10YR 3/2 very dark grayish brown (GP)		Bulk		Test Pit		
	5.0		CLAY, organic-H, high plasticity, mostly clay, some organic matter, little silt, wet (compressed peat), 10YR 3/3 dark brown (OH)						
	7.5		LIMESTONE						

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

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SAJ FORM 1836
JUN 03



Boring Designation: CP08-DCOMP-TP-0008

DRILLING LOG

1. PROJECT: C&SF CERP WCA 3 DECOMP	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 1 SHEETS
2. BORING DESIGNATION: CP08-DCOMP-TP-0008	LOCATION COORDINATES: X = 788,247 Y = 872,078	9. SIZE AND TYPE OF BIT: See Remarks	
3. DRILLING AGENCY: WPC, Inc.	CONTRACTOR FILE NO.	10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 VERTICAL: NAVD88
4. NAME OF DRILLER: Danny's Backhoe		11. MANUFACTURER'S DESIGNATION OF DRILL: CAT 320	☐ AUTO HAMMER ☐ MANUAL HAMMER
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	12. TOTAL SAMPLES: DISTURBED 3 UNDISTURBED (UD) 0
6. THICKNESS OF OVERBURDEN: N/A			13. TOTAL NUMBER CORE BOXES: 0
7. DEPTH DRILLED INTO ROCK: N/A			14. ELEVATION GROUND WATER: Depth 4.0 Ft.
8. TOTAL DEPTH OF BORING: 8.0 Ft.			15. DATE BORING: STARTED 10-16-08 COMPLETED 10-16-08
			16. ELEVATION TOP OF BORING: Not Determined
			17. TOTAL RECOVERY FOR BORING: N/A
			18. SIGNATURE AND TITLE OF INSPECTOR: Tom Casey, P.E., Geotechnical Engineer

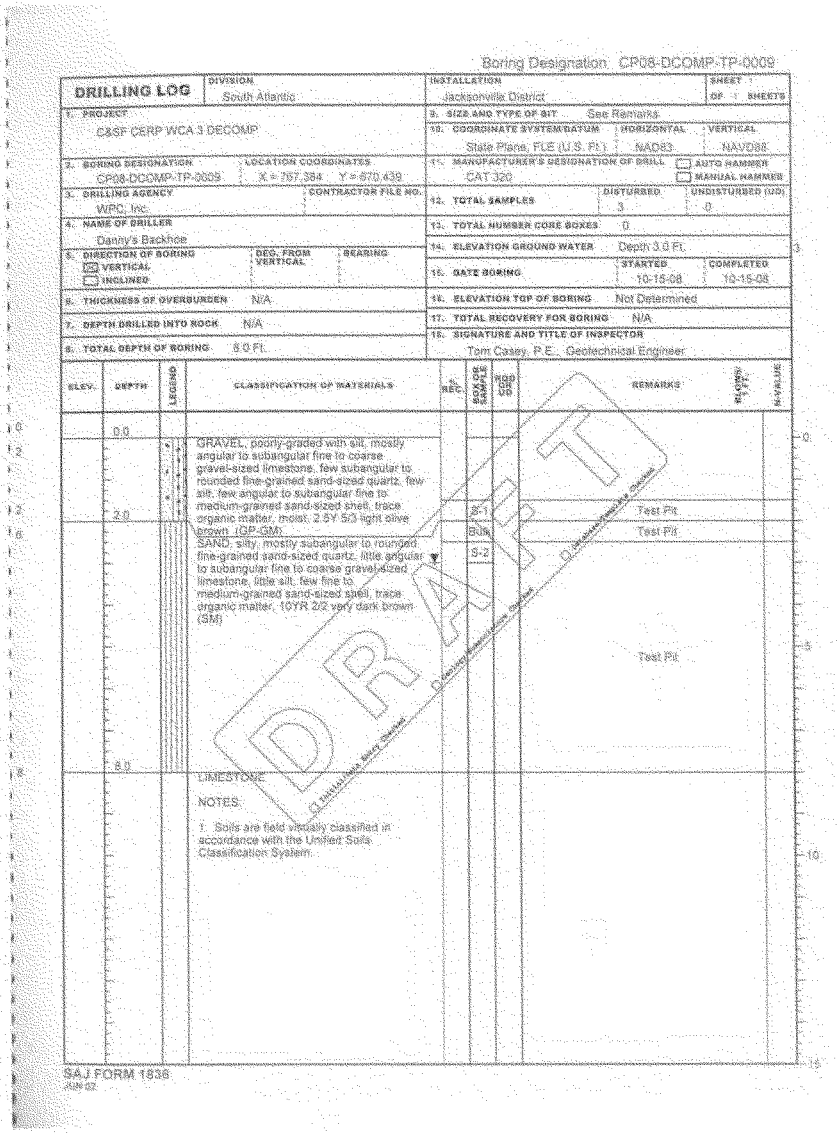
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR BARREL NO.	ROCK QD UD	REMARKS	BLOWS/FT.	N-VALUE
	0.0		GRAVEL, poorly-graded with silt, mostly angular to subangular fine to coarse gravel-sized limestone, little subangular to rounded fine-grained sand-sized quartz, few boulder-sized limestone, few silt, trace shell, moist, 2.5Y 6/3 light yellowish brown (GP-GM)		S-1		Test Pit		
	3.5		SAND, silty, mostly subangular to rounded fine-grained sand-sized quartz, some angular to subangular fine to coarse gravel-sized limestone, little silt, trace shell, 2.5Y 5/2 grayish brown (SM)		S-2		Test Pit		
	7.0		CLAY, organic-H, high plasticity, muddy clay, some organic matter, little silt, wet, (compressed peat), 10YR 3/3 dark brown (OH)		S-3		Test Pit		
	8.0		LIMESTONE						

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

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SAJ FORM 1836
JUN 02



Boring Designation: CP08-DCOMP-TP-0009

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District
SHEET: 1 OF 1 SHEETS	
1. PROJECT: CSSF CERP WCA 3 DECOMP	9. SIZE AND TYPE OF BIT: See Remarks
	10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP08-DCOMP-TP-0009 / LOCATION COORDINATES: X = 797,384 Y = 870,439	11. MANUFACTURER'S DESIGNATION OF DRILL: CAT 320 ☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: WPC, Inc. / CONTRACTOR FILE NO.:	12. TOTAL SAMPLES: DISTURBED 3 / UNDISTURBED (UD) 0
4. NAME OF DRILLER: Danny's Backhoe	13. TOTAL NUMBER CORE BOXES: 0
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED / DEG. FROM VERTICAL: / BEARING:	14. ELEVATION GROUND WATER: Depth 3.0 Ft.
	15. DATE BORING: STARTED 10-15-08 / COMPLETED 10-15-08
6. THICKNESS OF OVERBURDEN: N/A	16. ELEVATION TOP OF BORING: Not Determined
7. DEPTH DRILLED INTO ROCK: N/A	17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 8.0 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: Tom Casey, P.E., Geotechnical Engineer

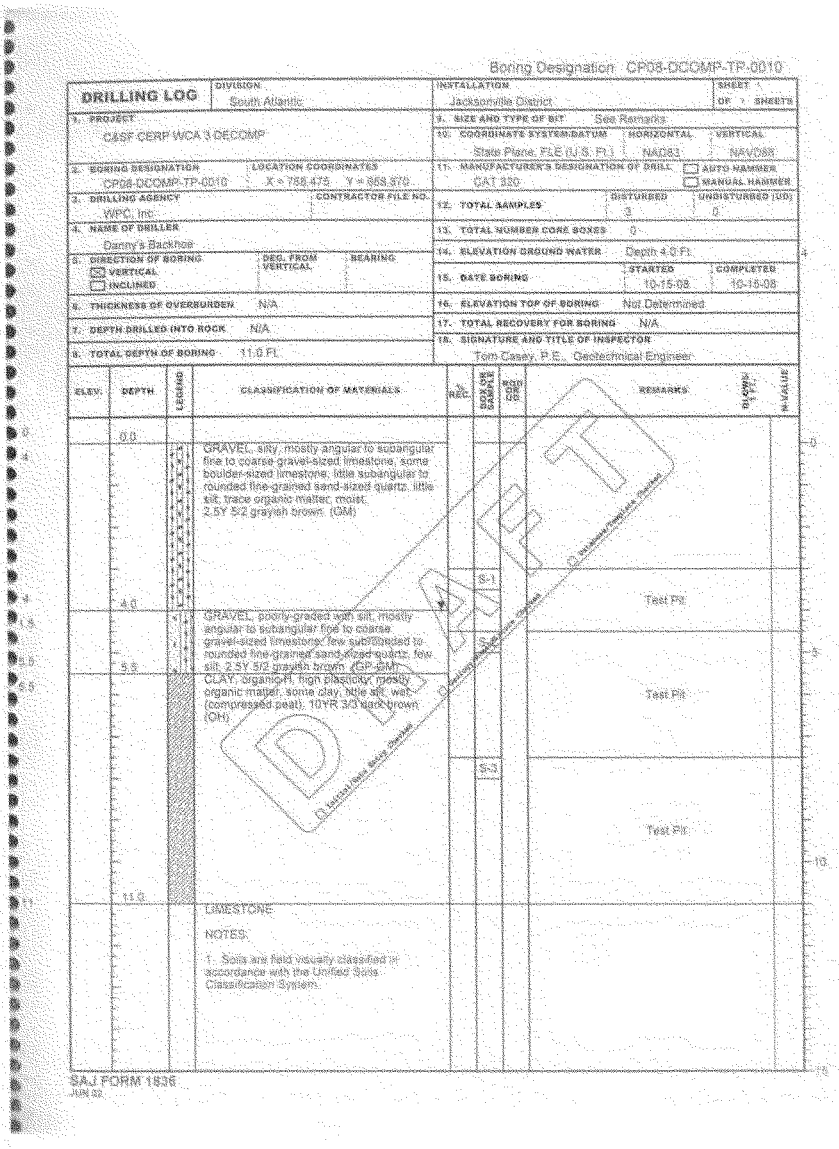
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	NO. REC.	BOX OR SAMPLE NO.	RQD OR UD	REMARKS	PENETRATION RESISTANCE (BLOWS/FT.)	MOISTURE
	0.0								
			GRAVEL, poorly-graded with silt, mostly angular to subangular fine to coarse gravel-sized limestone, few subangular to rounded fine-grained sand-sized quartz, few silt, few angular to subangular fine to medium-grained sand-sized shell, trace organic matter, moist, 2.5Y 5/3 light olive brown (GP-GM)		S-1		Test Pit		
					Bulk		Test Pit		
	2.0		SAND, silty, mostly subangular to rounded fine-grained sand-sized quartz, little angular to subangular fine to coarse gravel-sized limestone, little silt, few fine to medium-grained sand-sized shell, trace organic matter, 10YR 2/2 very dark brown (SM)		S-2		Test Pit		
	8.0		LIMESTONE						

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

SAJ FORM 1836
JUN 02

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Do Not Use for Construction Purposes
Pending Government Review
Do Not Use for Construction



Boring Designation CP08-DCOMP-TP-0010

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District
1. PROJECT: CASF CERP WCA 3 DECOMP	9. SIZE AND TYPE OF BIT: See Remarks
2. BORING DESIGNATION: CP08-DCOMP-TP-0010	LOCATION COORDINATES: X = 788,473 Y = 868,970
3. DRILLING AGENCY: WPC, Inc.	CONTRACTOR FILE NO.
4. NAME OF DRILLER: Danny's Backhoe	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL: BEARING:
6. THICKNESS OF OVERBURDEN: N/A	
7. DEPTH DRILLED INTO ROCK: N/A	
8. TOTAL DEPTH OF BORING: 11.0 Ft.	
10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) HORIZONTAL: NAD83 VERTICAL: NAVD88	
11. MANUFACTURER'S DESIGNATION OF DRILL: CAT 320 ☐ AUTO HAMMER ☐ MANUAL HAMMER	
12. TOTAL SAMPLES: DISTURBED: 3 UNDISTURBED (UD): 0	
13. TOTAL NUMBER CORE BOXES: 0	
14. ELEVATION GROUND WATER: Depth 4.0 Ft.	
15. DATE BORING: STARTED: 10-15-08 COMPLETED: 10-15-08	
16. ELEVATION TOP OF BORING: Not Determined	
17. TOTAL RECOVERY FOR BORING: N/A	
18. SIGNATURE AND TITLE OF INSPECTOR: Tom Casey, P.E., Geotechnical Engineer	

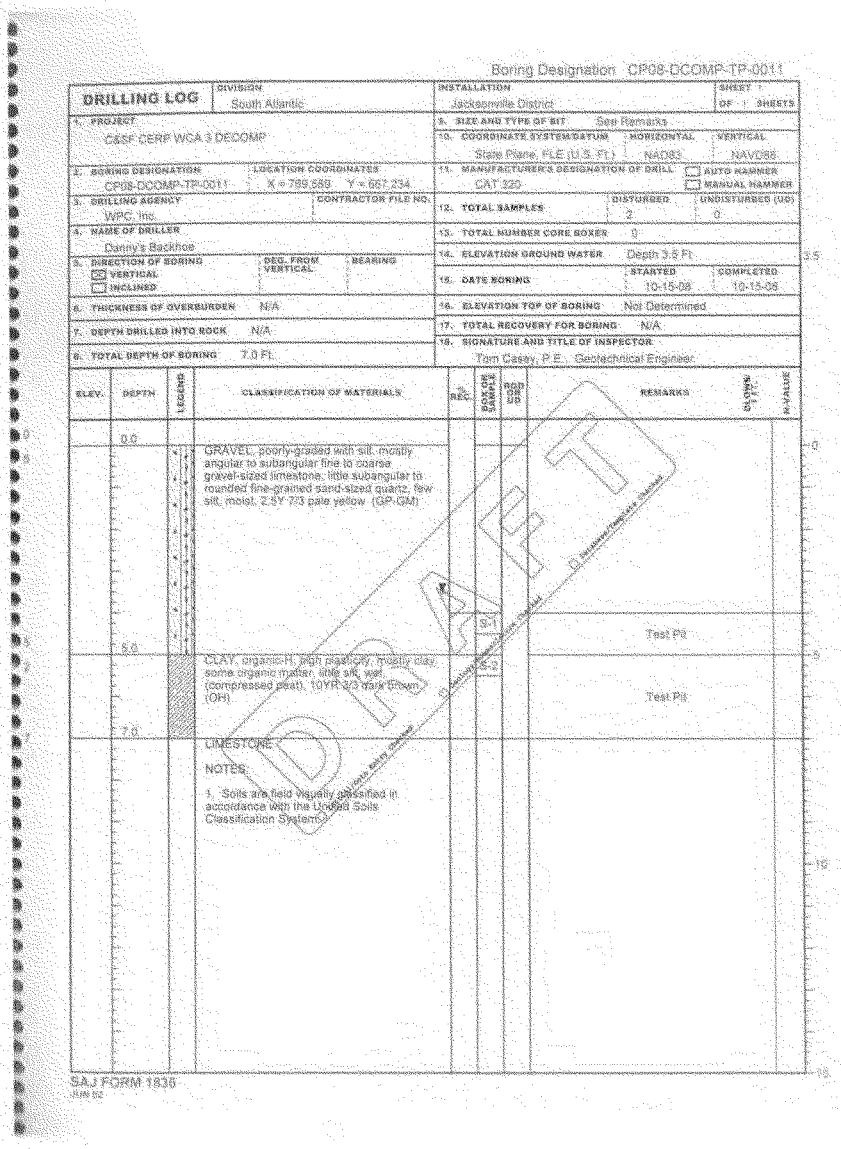
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	NO. REC.	SOIL OR GRAB SAMPLE	RECD. OF CO.	REMARKS	BLOWS/6 IN.	N-VALUE
	0.0		GRAVEL, silty, mostly angular to subangular fine to coarse gravel-sized limestone, some boulder-sized limestone, little subangular to rounded fine-grained sand-sized quartz, little silt, trace organic matter, moist, 2.5Y 5/2 grayish brown. (GM)						
	4.0				S-1		Test Pit		
	5.5		GRAVEL, poorly-graded with silt, mostly angular to subangular fine to coarse gravel-sized limestone, few subrounded to rounded fine-grained sand-sized quartz, few silt, 2.5Y 5/2 grayish brown. (GP-GM)		S-2		Test Pit		
	11.0		CLAY, organic-H, high plasticity, mostly organic matter, some clay, little silt, wet, (compressed peat), 10YR 3/3 dark brown. (OH)		S-3		Test Pit		
			LIMESTONE						

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

SAJ FORM 1836
JUN 92

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Deliberative/Pre-Decisional
For Internal Use Only



Boring Designation CP08-DCOMP-TP-0011

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District
1. PROJECT: CSSF CERP WCA 3 DECOMP	9. SIZE AND TYPE OF BIT: See Remarks
2. BORING DESIGNATION: CP08-DCOMP-TP-0011	LOCATION COORDINATES: X = 799,589 Y = 667,234
3. DRILLING AGENCY: WPC, Inc.	CONTRACTOR FILE NO.
4. NAME OF DRILLER: Danny's Backhoe	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL: BEARING:
6. THICKNESS OF OVERBURDEN: N/A	
7. DEPTH DRILLED INTO ROCK: N/A	
8. TOTAL DEPTH OF BORING: 7.0 Ft.	

10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. FT.)	HORIZONTAL: NAD83 VERTICAL: NAVD88
11. MANUFACTURER'S DESIGNATION OF DRILL: CAT 320	☐ AUTO HAMMER ☐ MANUAL HAMMER
12. TOTAL SAMPLES:	DISTURBED: 2 UNDISTURBED (UD): 0
13. TOTAL NUMBER CORE BOXES: 0	
14. ELEVATION GROUND WATER: Depth 3.5 Ft.	
15. DATE BORING:	STARTED: 10-15-08 COMPLETED: 10-15-08
16. ELEVATION TOP OF BORING: Not Determined	
17. TOTAL RECOVERY FOR BORING: N/A	
18. SIGNATURE AND TITLE OF INSPECTOR: Tom Casey, P.E., Geotechnical Engineer	

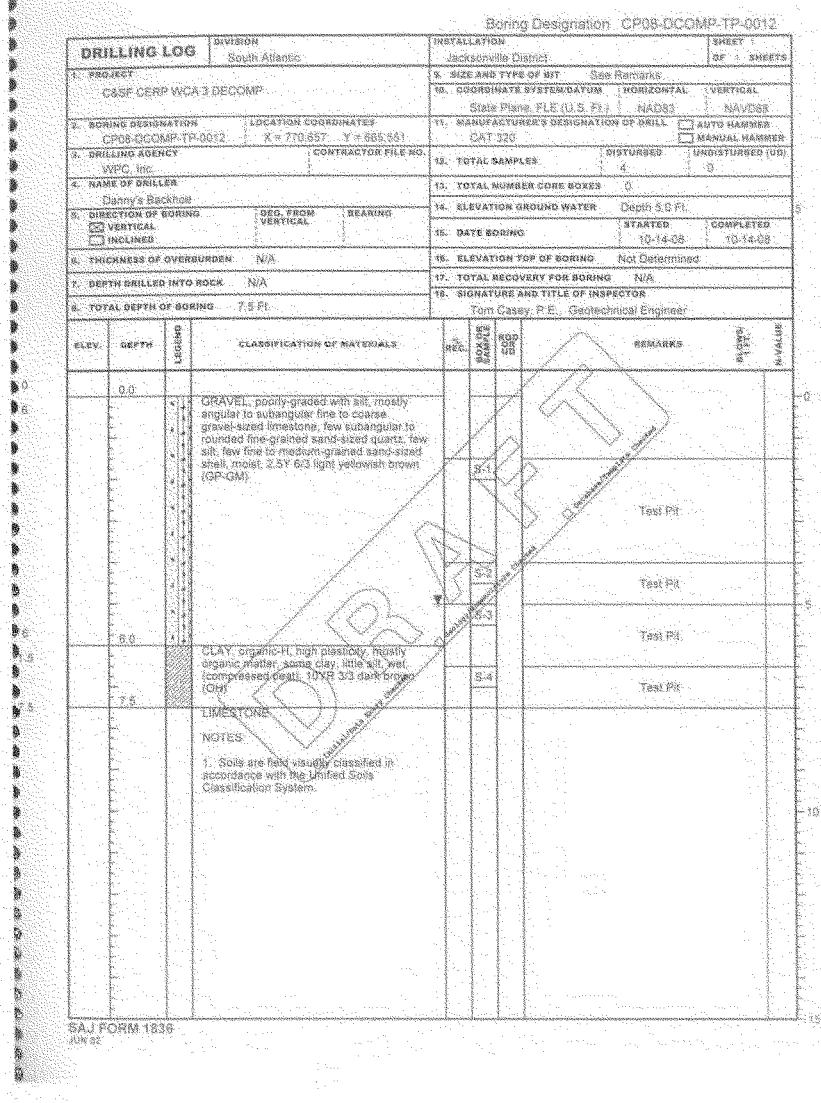
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX OR SAMPLE NO.	RQD OR UD	REMARKS	BLOWS / FT.	N-VALUE
	0.0		GRAVEL, poorly-graded with silt, mostly angular to subangular fine to coarse gravel-sized limestone, little subangular to rounded fine-grained sand-sized quartz, few silt, moist, 2.5Y 7/3 pale yellow (GP-GM)		S-1		Test Pit		
	5.0		CLAY, organic-H, high plasticity, mostly clay, some organic matter, little silt, wet (compressed peat), 10YR 2/3 dark brown (OH)		UD-1		Test Pit		
	7.0		LIMESTONE						

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

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SAJ FORM 1836
JUN 92



Boring Designation CP08-DCOMP-TP-0012

DRILLING LOG

DIVISION	South Atlantic
INSTALLATION	Jacksonville District
SHEET / OF SHEETS	
1. PROJECT	C&SF CERP WCA 3 DECOMP
9. SIZE AND TYPE OF BIT	See Remarks
10. COORDINATE SYSTEM/DATUM	State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION	CP08-DCOMP-TP-0012
LOCATION COORDINATES	X = 770,657 Y = 665,561
11. MANUFACTURER'S DESIGNATION OF DRILL	CAT 320
☐ AUTO HAMMER ☐ MANUAL HAMMER	
3. DRILLING AGENCY	WPC, Inc.
CONTRACTOR FILE NO.	
12. TOTAL SAMPLES	DISTURBED: 4 / UNDISTURBED (UD): 0
4. NAME OF DRILLER	Danny's Backhoe
13. TOTAL NUMBER CORE BOXES	0
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL / BEARING	
14. ELEVATION GROUND WATER	Depth 5.0 Ft.
15. DATE BORING	STARTED: 10-14-08 / COMPLETED: 10-14-08
6. THICKNESS OF OVERBURDEN	N/A
16. ELEVATION TOP OF BORING	Not Determined
7. DEPTH DRILLED INTO ROCK	N/A
17. TOTAL RECOVERY FOR BORING	N/A
8. TOTAL DEPTH OF BORING	7.5 Ft.
18. SIGNATURE AND TITLE OF INSPECTOR	Tom Casey, P.E., Geotechnical Engineer

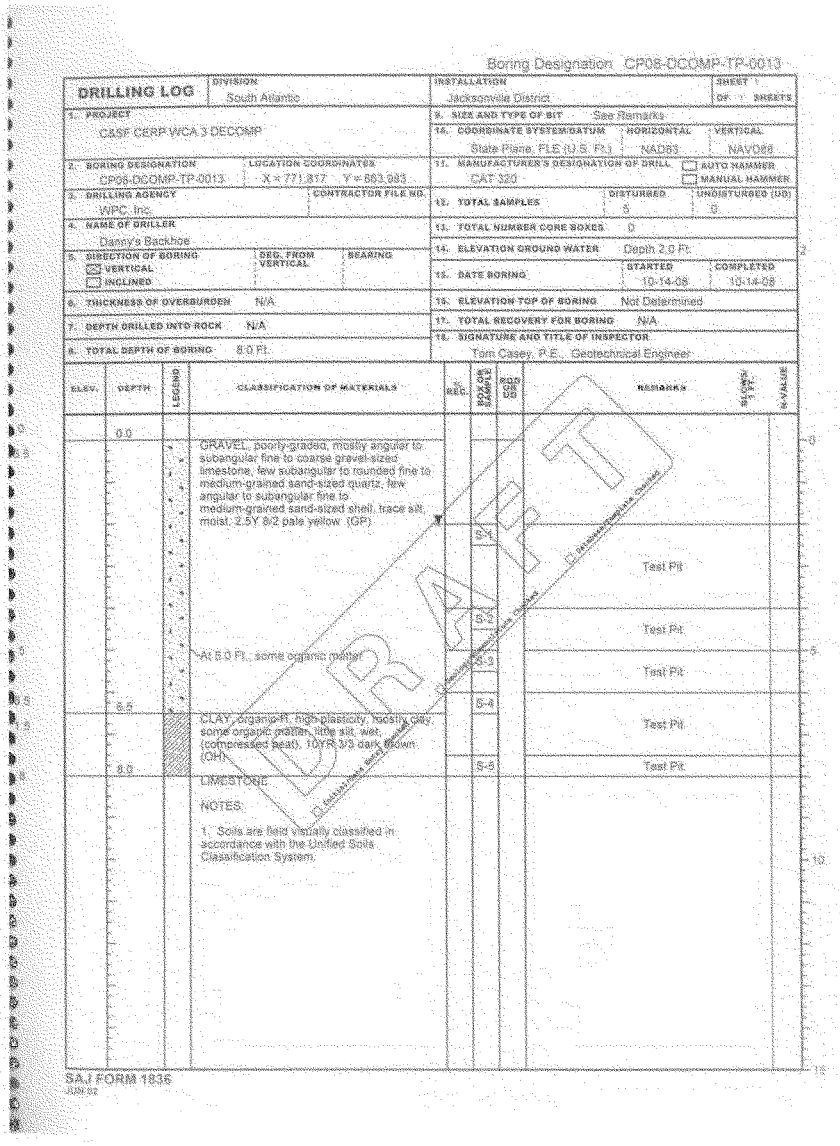
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD OR CORE	REMARKS	RECOVERY % / RQD	N-VALUE
	0.0		GRAVEL, poorly-graded with silt, mostly angular to subangular fine to coarse gravel-sized limestone, few subangular to rounded fine-grained sand-sized quartz, few silt, few fine to medium-grained sand-sized shell, moist, 2.5Y 6/3 light yellowish brown (GP-GM)		S-1		Test Pit		
					S-2		Test Pit		
					S-3		Test Pit		
	6.0		CLAY, organic-Pt, high plasticity, mostly organic matter, some clay, little silt, wet (compressed peat), 10YR 3/3 dark brown (OH)		S-4		Test Pit		
	7.5		LIMESTONE						

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

SAJ FORM 1836
JUN 82

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Boring Designation CP08-DCOMP-TP-0013

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 1 SHEETS
1. PROJECT: CASF CERP WCA 3 DECOMP		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 VERTICAL: NAVD88
2. BORING DESIGNATION: CP08-DCOMP-TP-0013	LOCATION COORDINATES: X = 771,817 Y = 863,983	11. MANUFACTURER'S DESIGNATION OF DRILL: CAT 320	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: WPC, Inc.	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED: 5 UNDISTURBED (UD): 0
4. NAME OF DRILLER: Danny's Backhoe		13. TOTAL NUMBER CORE BOXES: 0	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: Depth 2.0 Ft.
			15. DATE BORING: STARTED 10-14-08 COMPLETED 10-14-08
6. THICKNESS OF OVERBURDEN: N/A			16. ELEVATION TOP OF BORING: Not Determined
7. DEPTH DRILLED INTO ROCK: N/A			17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 8.0 Ft.			18. SIGNATURE AND TITLE OF INSPECTOR: Tom Casey, P.E., Geotechnical Engineer

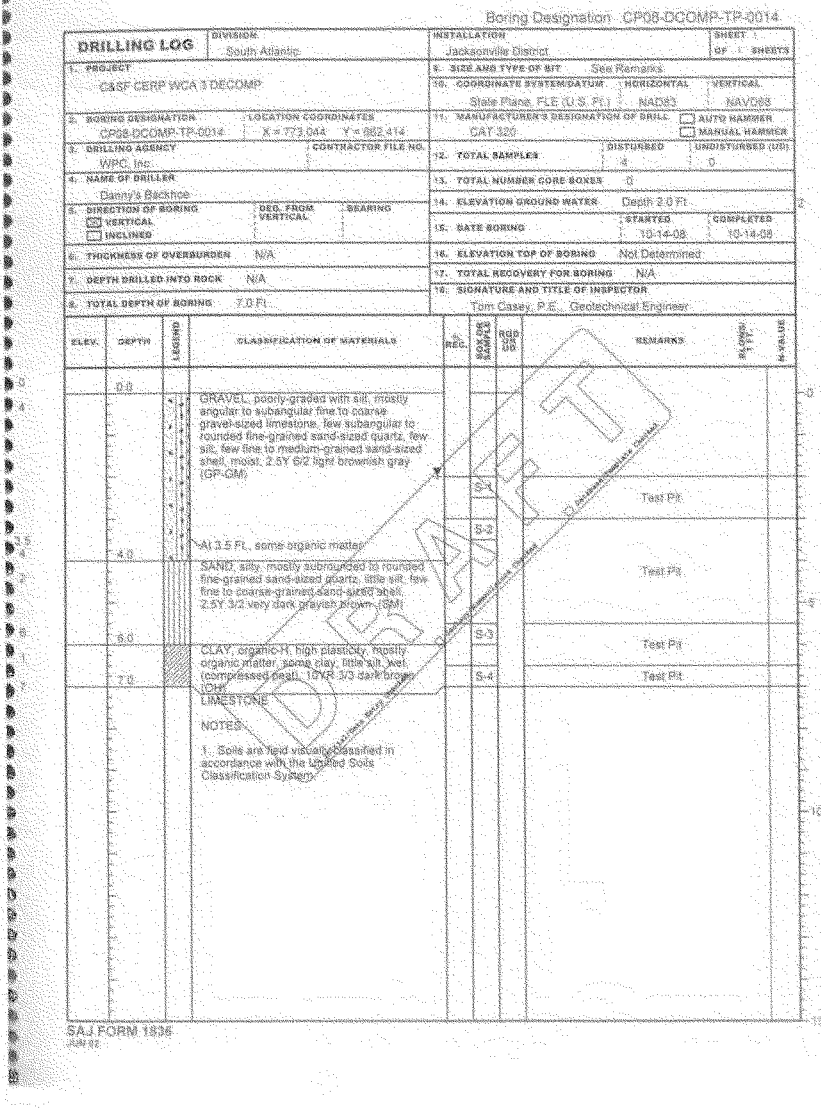
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	NO. REC.	ROCK SAMPLE	ROD DEPTH	REMARKS	BLOWS PER 6"	N-VALUE
	0.0		GRAVEL, poorly-graded, mostly angular to subangular fine to coarse gravel-sized limestone, few subangular to rounded fine to medium-grained sand-sized quartz, few angular to subangular fine to medium-grained sand-sized shell, trace silt, moist, 2.5Y 8/2 pale yellow (GP)		S-1		Test Pit		
					S-2		Test Pit		
			At 5.0 Ft., some organic matter		S-3		Test Pit		
	8.5		CLAY, organic-ft, high-plasticity, mostly clay, some organic matter, little silt, wet, (compressed peat), 10YR 3/3 dark brown (OH)		S-4		Test Pit		
	8.0		LIMESTONE		S-5		Test Pit		

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

SAJ FORM 1836
JUN 88

DRAFT
Document Name: CP08-DCOMP-TP-0013
Requested By: Tom Casey
Drawing Name: CP08-DCOMP-TP-0013



Boring Designation CP08-DCOMP-TP-0014

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: 1 OF 1 SHEETS	
1. PROJECT: C&SF CERP WCA 3 DECOMP	8. SIZE AND TYPE OF BIT: See Remarks		
2. BORING DESIGNATION: CP08-DCOMP-TP-0014	LOCATION COORDINATES: X = 773,044 Y = 882,414	10. COORDINATE SYSTEM/DATUM: State Plane FLE (U.S. Ft.)	HORIZONTAL: NAD83 VERTICAL: NAVD88
3. DRILLING AGENCY: WPC, Inc.	CONTRACTOR FILE NO.	11. MANUFACTURER'S DESIGNATION OF DRILL: CAT 320	☐ AUTO HAMMER ☐ MANUAL HAMMER
4. NAME OF DRILLER: Danny's Backhoe		12. TOTAL SAMPLES: DISTURBED 4 UNDISTURBED (UD) 0	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL: BEARING:	13. TOTAL NUMBER CORE BOXES: 0	
6. THICKNESS OF OVERBURDEN: N/A		14. ELEVATION GROUND WATER: Depth 2.0 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		15. DATE BORING: STARTED 10-14-08 COMPLETED 10-14-08	
8. TOTAL DEPTH OF BORING: 7.0 Ft.		16. ELEVATION TOP OF BORING: Not Determined	
		17. TOTAL RECOVERY FOR BORING: N/A	
		18. SIGNATURE AND TITLE OF INSPECTOR: Tom Casey, P.E., Geotechnical Engineer	

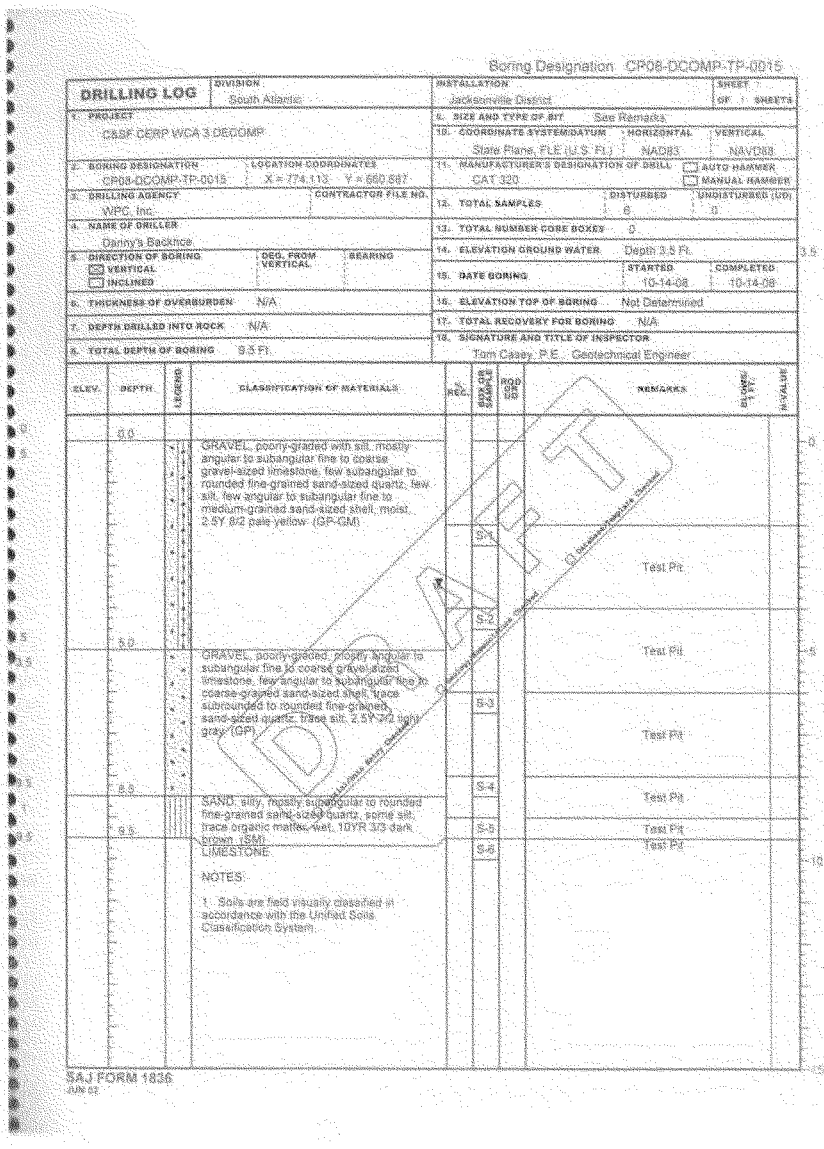
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	NO. REC.	MOX OR SAMPLE NO.	RQD OR UD	REMARKS	BLOWS/6 IN.	N-VALUE
	0.0		GRAVEL, poorly-graded with silt, mostly angular to subangular fine to coarse gravel-sized limestone, few subangular to rounded fine-grained sand-sized quartz, few silt, few fine to medium-grained sand-sized shell, moist, 2.5Y 6/2 light brownish gray (GP-GM)		S-1		Test Pit		
	4.0		At 3.5 Ft., some organic matter		S-2		Test Pit		
	6.0		SAND, silty, mostly subrounded to rounded fine-grained sand-sized quartz, little silt, few fine to coarse-grained sand-sized shell, 2.5Y 3/3 very dark grayish brown (SM)		S-3		Test Pit		
	7.0		CLAY, organic-H, high plasticity, mostly organic matter, some clay, little silt, wet (compressed peat), 10YR 3/3 dark brown (OH)		S-4		Test Pit		
			LIMESTONE						

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

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JUN 92



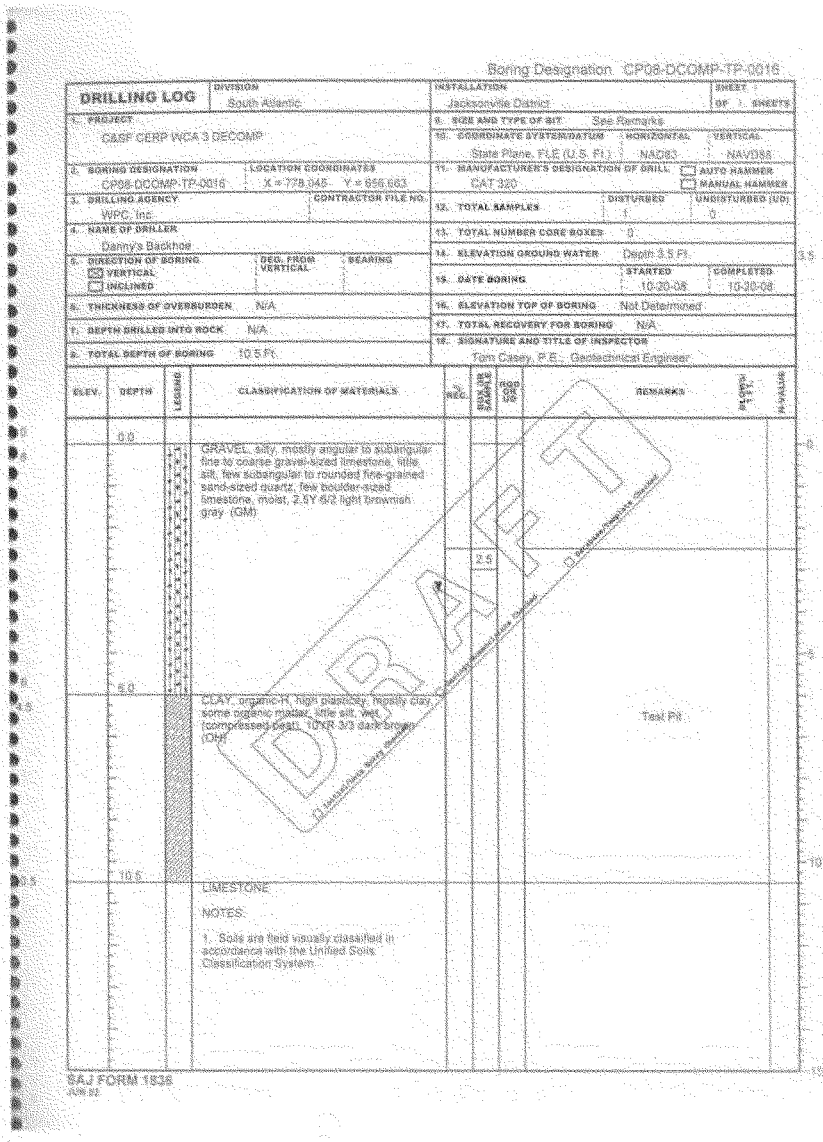
Boring Designation CP08-DCOMP-TP-0015

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District
SHEET: OF SHEETS	
1. PROJECT: CSSF CERP WCA 3 DECOMP	9. SIZE AND TYPE OF BIT: See Remarks
2. BORING DESIGNATION: CP08-DCOMP-TP-0015	LOCATION COORDINATES: X = 774,113 Y = 660,587
10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 VERTICAL: NAVD88
3. DRILLING AGENCY: WPC, Inc.	CONTRACTOR FILE NO.
11. MANUFACTURER'S DESIGNATION OF DRILL: CAT 320	☐ AUTO HAMMER ☐ MANUAL HAMMER
4. NAME OF DRILLER: Danny's Backhoe	12. TOTAL SAMPLES: DISTURBED 6 UNDISTURBED (UD) 0
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL: BEARING:
13. TOTAL NUMBER CORE BOXES: 0	
6. THICKNESS OF OVERBURDEN: N/A	14. ELEVATION GROUND WATER: Depth 3.5 Ft.
7. DEPTH DRILLED INTO ROCK: N/A	15. DATE BORING: STARTED 10-14-08 COMPLETED 10-14-08
8. TOTAL DEPTH OF BORING: 9.5 Ft.	16. ELEVATION TOP OF BORING: Not Determined
	17. TOTAL RECOVERY FOR BORING: N/A
	18. SIGNATURE AND TITLE OF INSPECTOR: Tom Casey, P.E. Geotechnical Engineer

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD SIZE	REMARKS	BLOWS / FT.	N-VALUE
0	0.0								
-5			GRAVEL, poorly-graded with silt, mostly angular to subangular fine to coarse gravel-sized limestone, few subangular to rounded fine-grained sand-sized quartz, few silt, few angular to subangular fine to medium-grained sand-sized shell, moist, 2.5Y 8/2 pale yellow (GP-GM)		S-1		Test Pit		
					S-2		Test Pit		
-5	5.0		GRAVEL, poorly-graded, mostly angular to subangular fine to coarse gravel-sized limestone, few angular to subangular fine to coarse-grained sand-sized shell, trace subrounded to rounded fine-grained sand-sized quartz, trace silt, 2.5Y 7/2 light gray (GP)		S-3		Test Pit		
	8.5				S-4		Test Pit		
-5	9.5		SAND, silty, mostly subangular to rounded fine-grained sand-sized quartz, some silt, trace organic matter, wet, 10YR 3/3 dark brown (SM)		S-5		Test Pit		
			LIMESTONE		S-6		Test Pit		
-10			NOTES: 1. Soils are field visually classified in accordance with the Unified Soils Classification System.						

SAJ FORM 1836
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Boring Designation CP08-DCOMP-TP-0016

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District
SHEET: OF SHEETS	
1. PROJECT: CASF CERP WCA 3 DECOMP	9. SIZE AND TYPE OF BIT: See Remarks
10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 VERTICAL: NAVD88
2. BORING DESIGNATION: CP08-DCOMP-TP-0016	LOCATION COORDINATES: X = 778,045 Y = 656,663
11. MANUFACTURER'S DESIGNATION OF DRILL: CAT 320	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: WPC, Inc.	CONTRACTOR FILE NO.
12. TOTAL SAMPLES: 1	DISTURBED: 1 UNDISTURBED (UD): 0
4. NAME OF DRILLER: Danny's Backhoe	13. TOTAL NUMBER CORE BOXES: 0
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL: BEARING:
14. ELEVATION GROUND WATER: Depth 3.5 Ft.	
15. DATE BORING:	STARTED: 10-20-08 COMPLETED: 10-20-08
6. THICKNESS OF OVERBURDEN: N/A	16. ELEVATION TOP OF BORING: Not Determined
7. DEPTH DRILLED INTO ROCK: N/A	17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 10.5 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: Tom Casey, P.E., Geotechnical Engineer

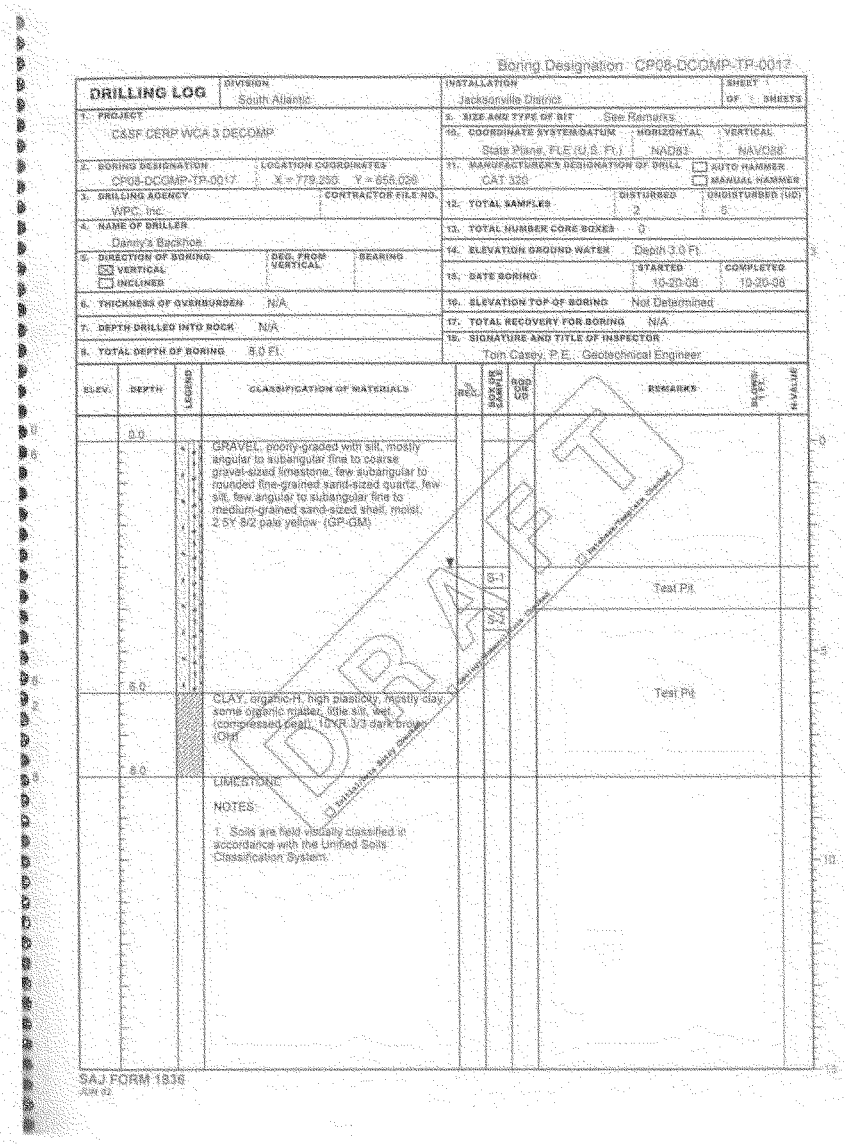
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	NO. REC.	TYPE OF SAMPLE	BLOWS ON ROD OR CASING	REMARKS	WATER LEVEL	PEN. OR REC.
	0.0		GRAVEL, silty, mostly angular to subangular fine to coarse gravel-sized limestone, little silt, few subangular to rounded fine-grained sand-sized quartz, few boulder-sized limestone, moist, 2.5Y 6/2 light brownish gray (GM)	1		2.5	Test Pit		
	6.0		CLAY, organic-H, high plasticity, mostly clay, some organic matter, little silt, wet, (compressed peat), 10YR 3/3 dark brown (OH)						
	10.5		LIMESTONE						

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

DRAFT

SAJ FORM 1835
JUN 91



Boring Designation: CP08-DCOMP-TP-0017

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District
SHEET: OF: SHEETS	
1. PROJECT: C&SF CERP WCA 3 DECOMP	9. SIZE AND TYPE OF BIT: See Remarks
2. BORING DESIGNATION: CP08-DCOMP-TP-0017	LOCATION COORDINATES: X = 779,255 Y = 655,039
10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 VERTICAL: NAVD88
3. DRILLING AGENCY: WPC, Inc.	CONTRACTOR FILE NO.
11. MANUFACTURER'S DESIGNATION OF DRILL: CAT 320	☐ AUTO HAMMER ☐ MANUAL HAMMER
4. NAME OF DRILLER: Danny's Backhoe	12. TOTAL SAMPLES: DISTURBED 2 UNDISTURBED (UD) 5
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL: BEARING:
13. TOTAL NUMBER CORE BOXES: 0	
6. THICKNESS OF OVERBURDEN: N/A	14. ELEVATION GROUND WATER: Depth 3.0 Ft.
7. DEPTH DRILLED INTO ROCK: N/A	15. DATE BORING: STARTED 10-29-08 COMPLETED 10-30-08
8. TOTAL DEPTH OF BORING: 8.0 Ft.	16. ELEVATION TOP OF BORING: Not Determined
	17. TOTAL RECOVERY FOR BORING: N/A
	18. SIGNATURE AND TITLE OF INSPECTOR: Tom Casey, P.E., Geotechnical Engineer

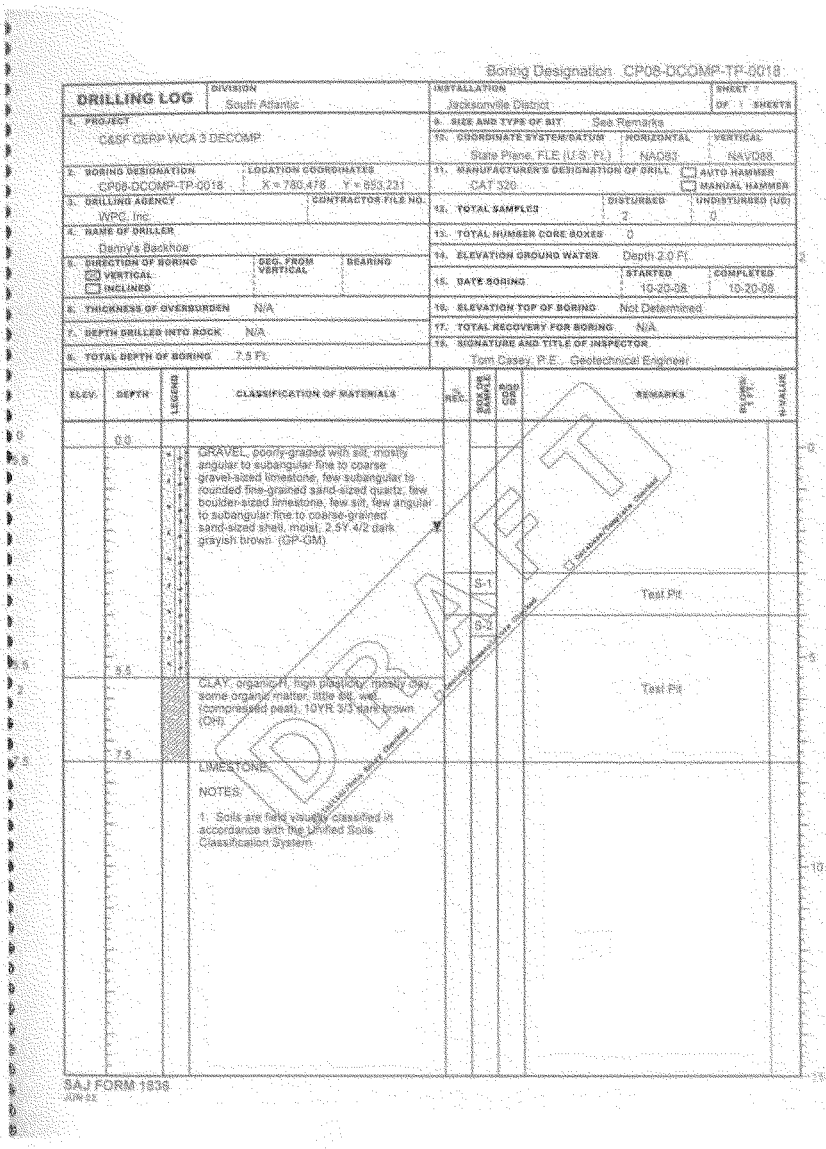
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX OR SAMPLE NO.	ROD OR CORE	REMARKS	BLOWS/FT.	PEN. OR REC.
	0.0								
			GRAVEL, poorly-graded with silt, mostly angular to subangular fine to coarse gravel-sized limestone, few subangular to rounded fine-grained sand-sized quartz, few silt, few angular to subangular fine to medium-grained sand-sized shell, moist, 2.5Y 8/2 pale yellow (GP-GM)		S-1		Test Pit		
	5.0		CLAY, organic-H, high plasticity, mostly clay, some organic matter, little silt, wet (compressed peat), 10YR 3/3 dark brown (OH)		S-2		Test Pit		
	8.0		LIMESTONE						

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

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SAJ FORM 1836
JUN 92



Boring Designation CP08-DCOMP-TP-0018

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District
SHEET 1 OF 1 SHEETS	
1. PROJECT: CESF CERP WCA 3 DECOMP	9. SIZE AND TYPE OF BIT: See Remarks
2. BORING DESIGNATION: CP08-DCOMP-TP-0018	LOCATION COORDINATES: X = 780,478 Y = 853,231
10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 VERTICAL: NAVD88
3. DRILLING AGENCY: WPC, Inc.	CONTRACTOR'S FILE NO.
11. MANUFACTURER'S DESIGNATION OF DRILL: CAT 320	☐ AUTO HAMMER ☐ MANUAL HAMMER
4. NAME OF DRILLER: Danny's Backhoe	12. TOTAL SAMPLES: DISTURBED 2 UNDISTURBED (UD) 0
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL: BEARING:
13. TOTAL NUMBER CORE BOXES: 0	
14. ELEVATION GROUND WATER: Depth 2.0 Ft.	
15. DATE BORING: STARTED 10-20-08 COMPLETED 10-20-08	
6. THICKNESS OF OVERBURDEN: N/A	16. ELEVATION TOP OF BORING: Not Determined
7. DEPTH DRILLED INTO ROCK: N/A	17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 7.5 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: Tom Casey, P.E., Geotechnical Engineer

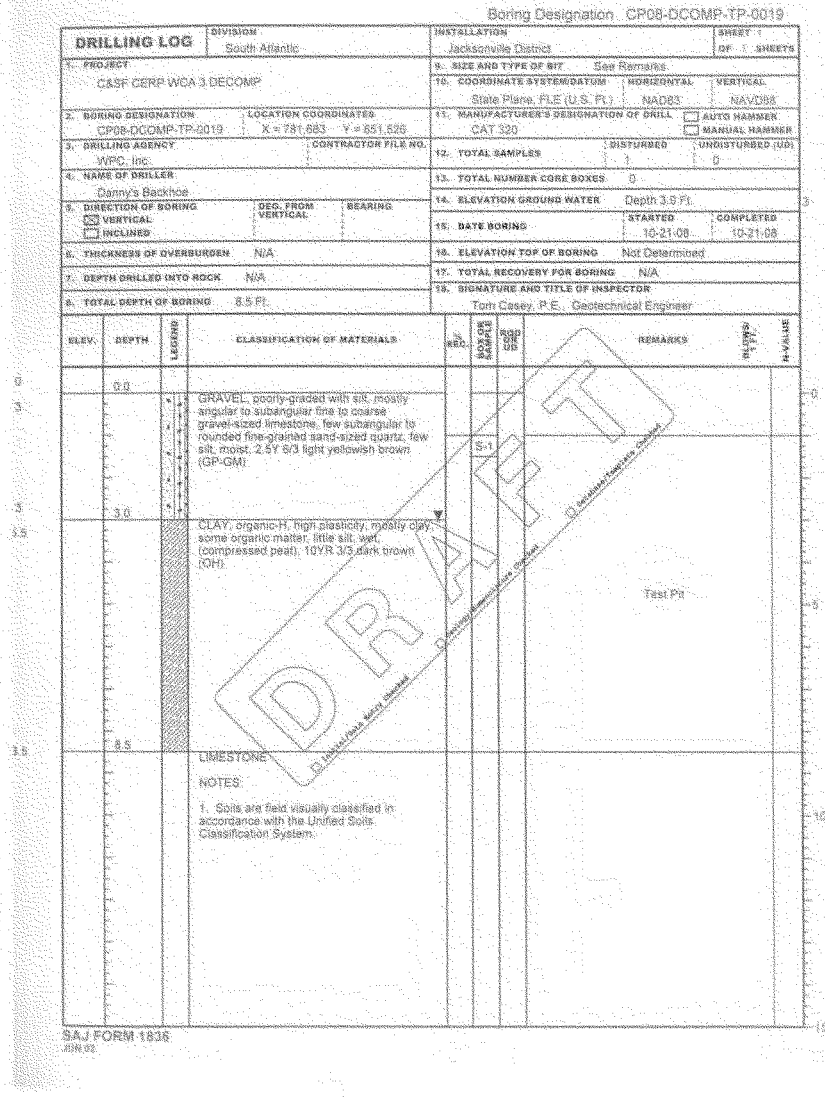
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	SOIL OR ROCK SAMPLE	SOIL OR CORE	REMARKS	BLOWS PER 6 IN.	N-VALUE
0	0.0		GRAVEL, poorly-graded with silt, mostly angular to subangular fine to coarse gravel-sized limestone, few subangular to rounded fine-grained sand-sized quartz, few boulder-sized limestone, few silt, few angular to subangular fine to coarse-grained sand-sized shell, moist, 2.5Y 4/2 dark grayish brown (GP-GM)						
-2.5					S-1		Test Pit		
-5.0	5.5				S-2				
			CLAY, organic-ft, high plasticity, mostly clay, some organic matter, little silt, wet, (compressed peat), 10YR 3/3 dark brown (OH)				Test Pit		
-7.5	7.5								
			LIMESTONE						

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System

SAJ FORM 1838
JAN 92

DRAFT



Boring Designation: CP08-DCOMP-TP-0019

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District
SHEET: 1 OF 1 SHEETS	
1. PROJECT: C&SF CERP WCA 3 DECOMP	9. SIZE AND TYPE OF BIT: See Remarks
	10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP08-DCOMP-TP-0019 / LOCATION COORDINATES: X = 781,683 Y = 851,526	11. MANUFACTURER'S DESIGNATION OF DRILL: CAT 320 / ☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: WPC, Inc. / CONTRACTOR FILE NO.:	12. TOTAL SAMPLES: DISTURBED 1 / UNDISTURBED (UD) 0
4. NAME OF DRILLER: Danny's Backhoe	13. TOTAL NUMBER CORE BOXES: 0
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED / DEG. FROM VERTICAL: / BEARING:	14. ELEVATION GROUND WATER: Depth 3.0 Ft.
	15. DATE BORING: STARTED 10-21-08 / COMPLETED 10-21-08
6. THICKNESS OF OVERBURDEN: N/A	16. ELEVATION TOP OF BORING: Not Determined
7. DEPTH DRILLED INTO ROCK: N/A	17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 8.5 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: Tom Casey, P.E., Geotechnical Engineer

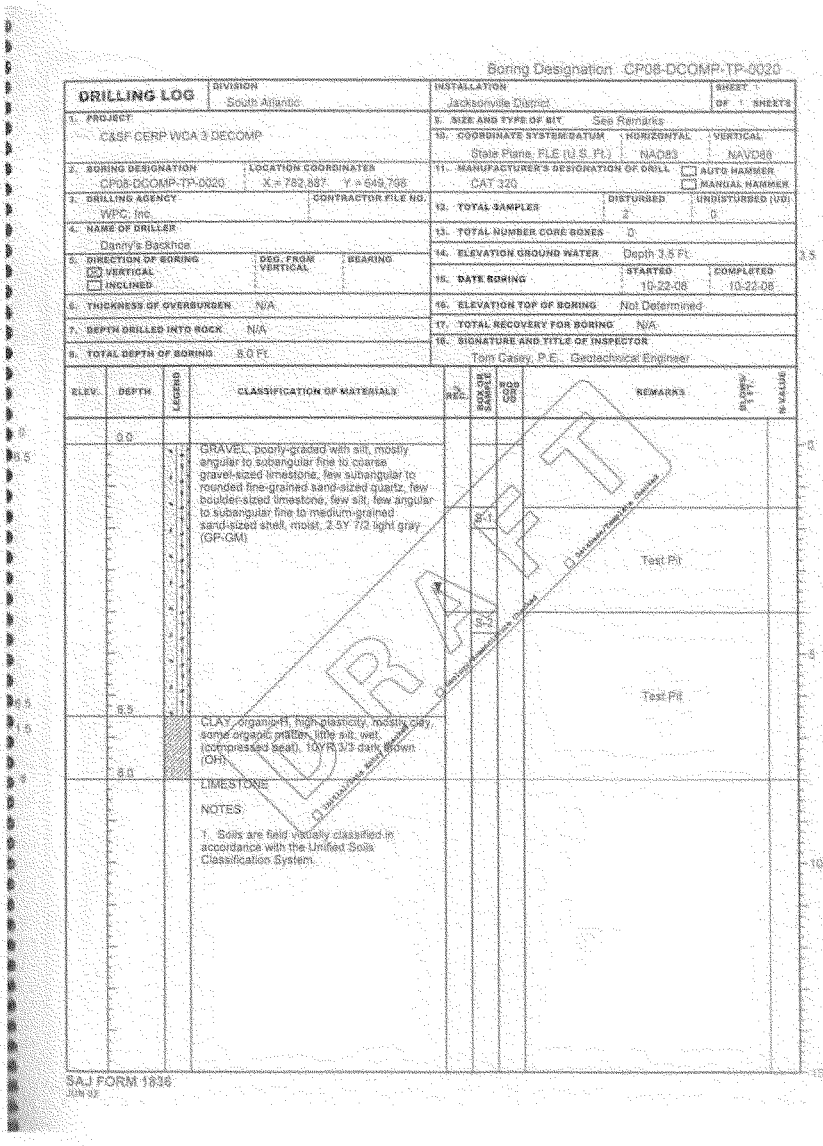
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX OR SAMPLE NO.	RQD OR UD	REMARKS	BLOWS/FT.	PI VALUE
0	0.0		GRAVEL, poorly-graded with silt, mostly angular to subangular fine to coarse gravel-sized limestone, few subangular to rounded fine-grained sand-sized quartz, few silt, moist, 2.5Y 6/3 light yellowish brown (GP-GM)		S-1				
-3	3.0		CLAY, organic-H, high plasticity, mostly clay, some organic matter, little silt, wet, (compressed peat), 10YR 3/3 dark brown (OH)				Test Pit		
-5.5	8.5		LIMESTONE						

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

DRAFT

SAJ FORM 1836
JUN 02



Boring Designation: CP08-DCOMP-TP-0020

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: 1 OF 1 SHEETS	
1. PROJECT: C&SF CERP WCA 3 DECOMP	9. SIZE AND TYPE OF BIT: See Remarks		
	10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83	VERTICAL: NAVD88
2. BORING DESIGNATION: CP08-DCOMP-TP-0020	LOCATION COORDINATES: X = 782,887 Y = 649,798	11. MANUFACTURER'S DESIGNATION OF DRILL: CAT 320	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: WPC, Inc	CONTRACTOR FILE NO.	12. TOTAL SAMPLES:	DISTURBED: 2 UNDISTURBED (UD): 0
4. NAME OF DRILLER: Danny's Backhoe		13. TOTAL NUMBER CORE BOXES: 0	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL:	BEARING:	14. ELEVATION GROUND WATER: Depth 3.5 Ft.
			15. DATE BORING: STARTED 10-22-08 COMPLETED 10-22-08
6. THICKNESS OF OVERBURDEN: N/A			16. ELEVATION TOP OF BORING: Not Determined
7. DEPTH DRILLED INTO ROCK: N/A			17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 8.0 Ft.			18. SIGNATURE AND TITLE OF INSPECTOR: Tom Casey, P.E., Geotechnical Engineer

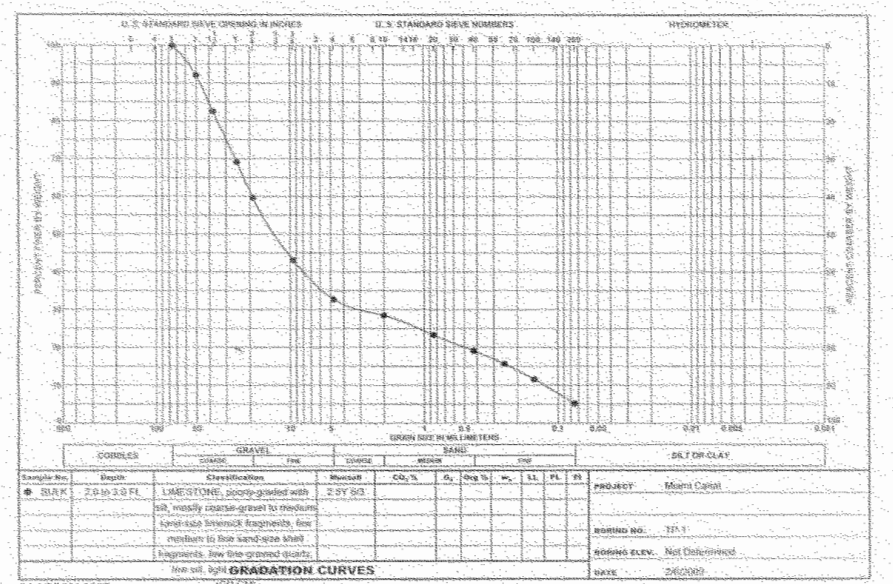
ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX OR SAMPLE NO.	ROD OR CORE	REMARKS	BLOWS/6 IN.	N-VALUE
3.5	0.0		GRAVEL, poorly-graded with silt, mostly angular to subangular fine to coarse gravel-sized limestone, few subangular to rounded fine-grained sand-sized quartz, few boulder-sized limestone, few silt, few angular to subangular fine to medium-grained sand-sized shell, moist, 2.5Y 7/2 light gray (GP-GM)		SS-1		Test Pit		
					SS-2		Test Pit		
-5.5	9.0		CLAY, organic-H, high plasticity, mostly clay, some organic matter, little silt, wet, (compressed peat), 10YR 3/3 dark brown (OH)						
-8.0	11.5		LIMESTONE						

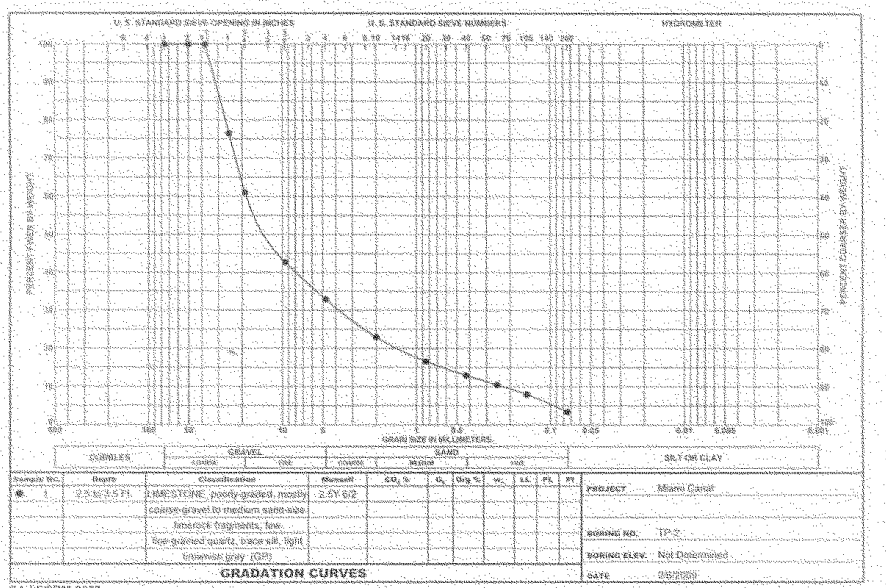
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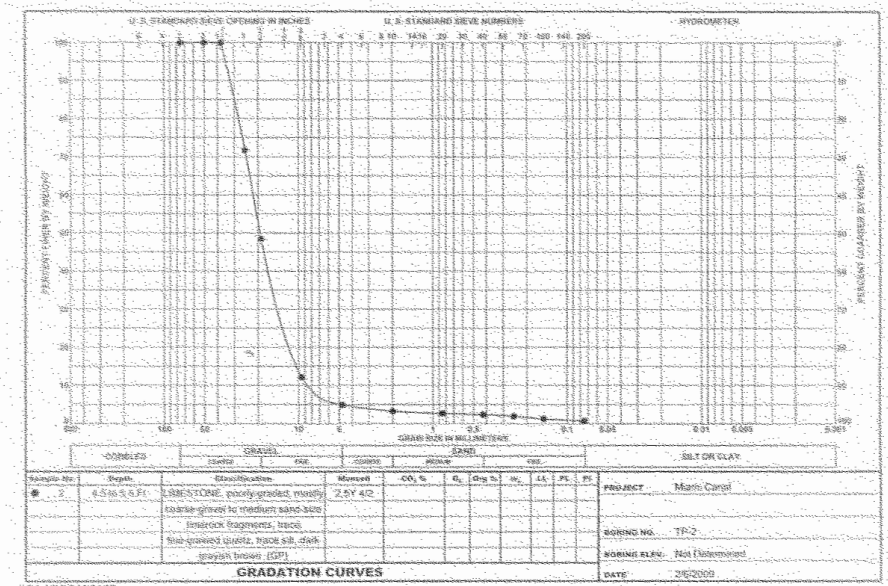
1. Soils are field visually classified in accordance with the Unified Soils Classification System.

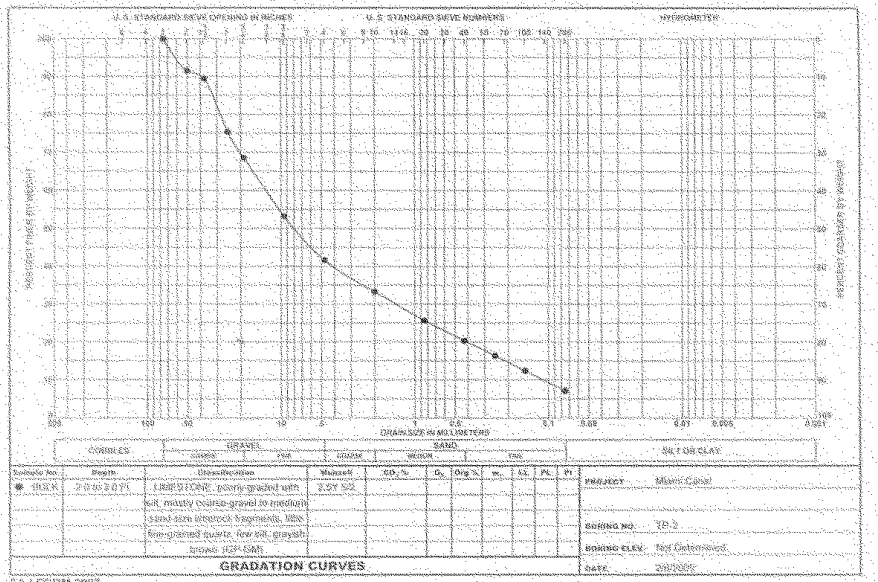
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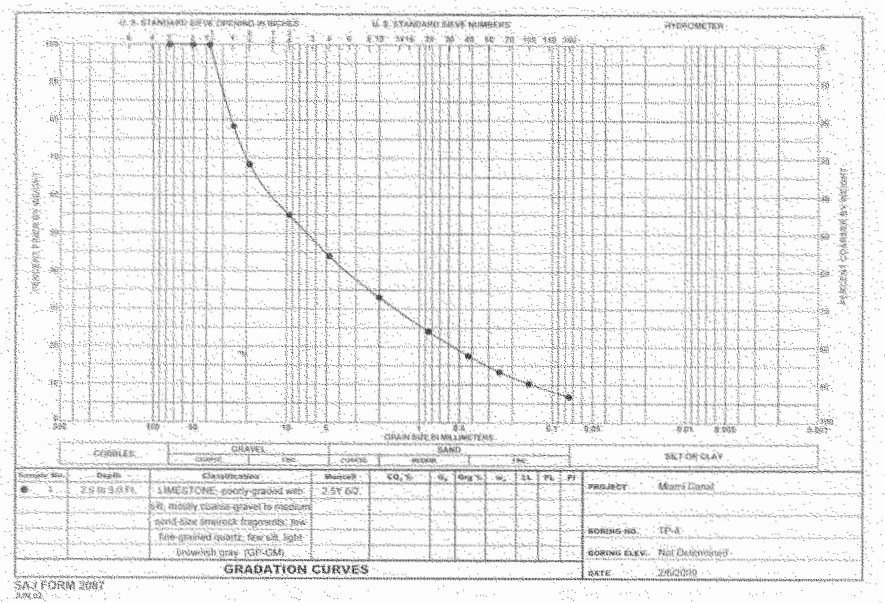
SAJ FORM 1836
JUN 97

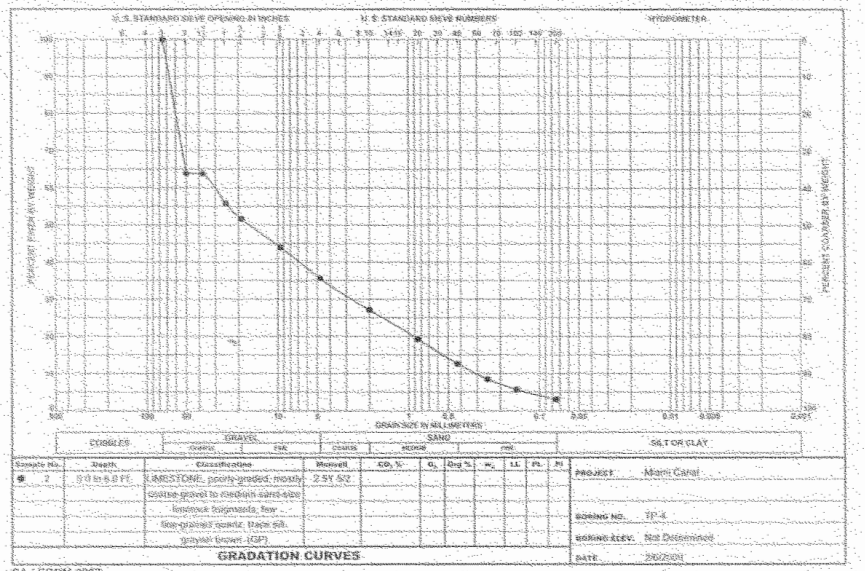

U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
COARSE
FINE
COARSE
MEDIUM
FINE
Sample No.
Depth
Classification
Remarks
CO_3 %
G_s
Org %
w_n
LL
PL
PI
B-LEK
7.0 to 9.0 Ft
LIMESTONE, poorly-graded with silt, mostly coarse gravel to medium sand-size limerock fragments, few medium to fine sand-size shell fragments, few fine grained quartz, few silt, light
2.5Y 8/3
GRADATION CURVES
(GP-GM)
PROJECT
Miami Canal
BORING NO.
TP-1
BORING ELEV.
Not Determined
DATE
2/6/2009
SAJ FORM 2087
JUN 02

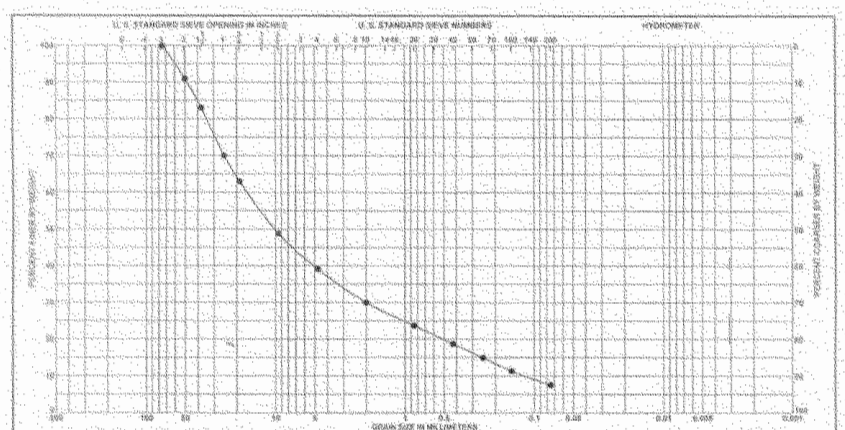

U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
Sample No. | Depth | Classification | Remark | LL % | PL | PI | W
1 | 0 ft to 2.5 ft | LIMESTONE, poorly graded, mostly coarse gravel to medium sand size, limerock fragments, fine, fine grained quartz, trace silt, light brownish gray (10R)
PROJECT Miami Canal
BORING NO. TP-2
BORING ELEV. Not Determined
DATE
GRADATION CURVES
SAJ FORM 2087
JUN 01

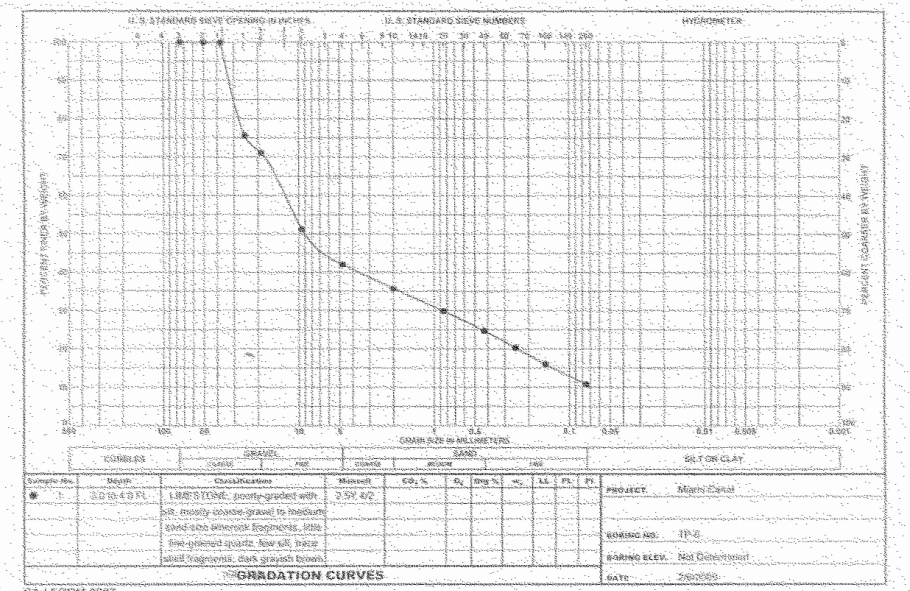

U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
Sample No.
Depth
Classification
Munsell
CO_3 %
G_s
Org %
w_n
LL
PL
PI
4.5 to 5.5 Ft
LIMESTONE, poorly graded, mostly coarse gravel to medium sand-size limerock fragments, trace, fine-grained quartz, trace silt, dark grayish brown (GP)
2.5Y 4/2
PROJECT
Marin Canal
BORING NO.
TP-2
BORING ELEV.
Not Determined
DATE
2/6/2009
GRADATION CURVES
SAJ FORM 2967
FIR 65


U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
Sample No.
Depth
Classification
Remarks
LL
PL
PI
PROJECT
BORING NO.
BORING ELEV.
DATE
GRADATION CURVES
SAJ FORM 2087

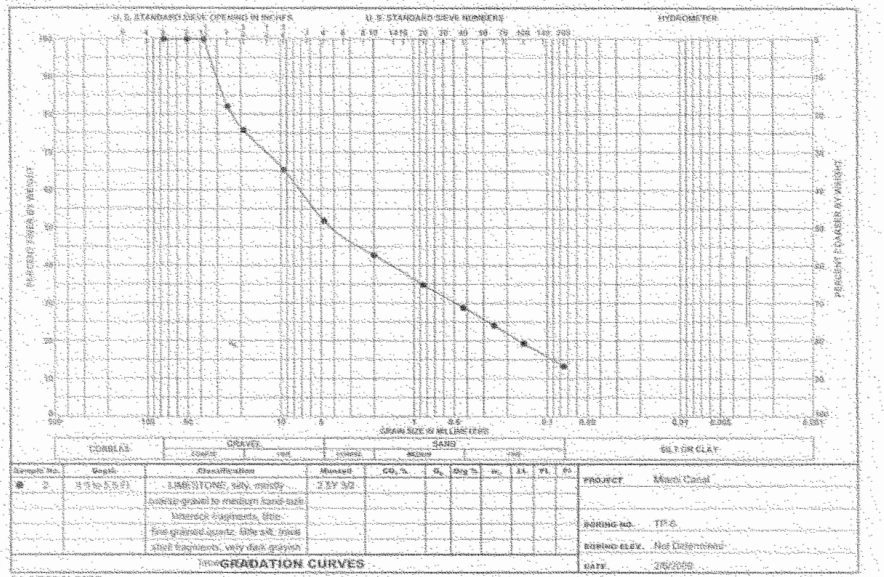

U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENTAGE COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
Sample No.
Depth
Classification
Munsell
CO3 %
Gs
Org %
wn
LL
PL
PI
2.5 ft to 5.0 ft
LIMESTONE: poorly-graded with silt, mostly coarse gravel to medium sand-size limerock fragments; few fine-grained quartz; few silt; light brownish gray (GP-GM)
2.5Y 6/2
PROJECT
Miami Canal
BORING NO.
TP-3
BORING ELEV.
Not Determined
DATE
2/6/2009
GRADATION CURVES
SAJ FORM 2087
JUN 02

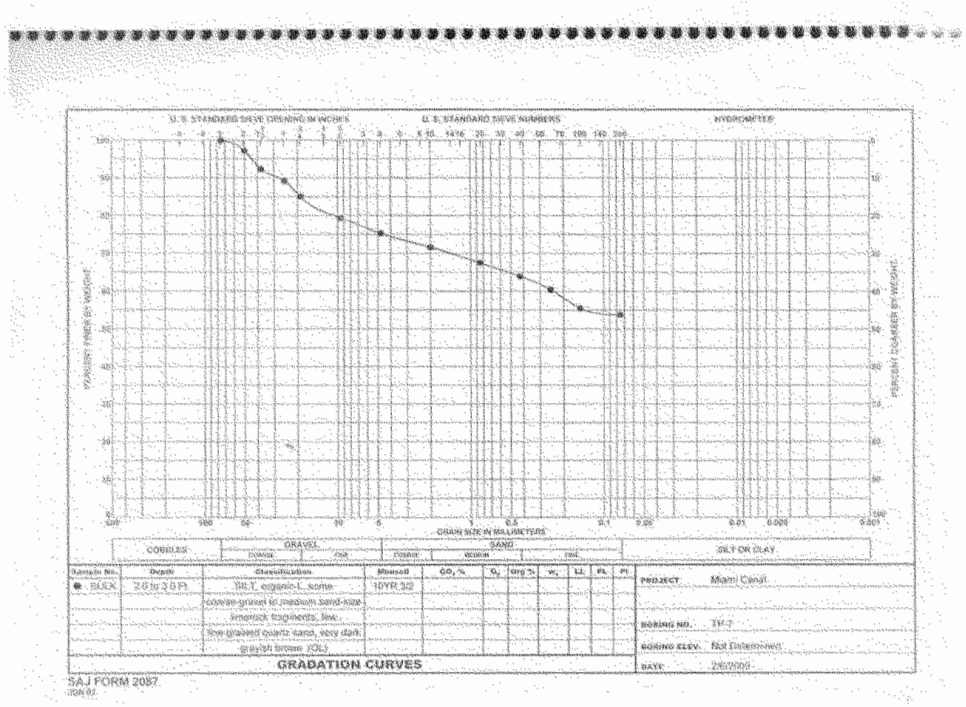

U.S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
Sample No.
Depth
Classification
Moisture
CO, %
G,
Dry %
w,
LL
PL
PI
2
5.0 to 6.0 FT
LIMESTONE, poorly-graded, mostly coarse gravel to medium sand-size fragments, few fine gravel, trace silt, brown (GP)
2.5Y 5/2
PROJECT
Miami Canal
BORING NO.
TP-4
BORING ELEV.
Not Determined
DATE
20120301
GRADATION CURVES
SAJ FORM 2087
JUN 97

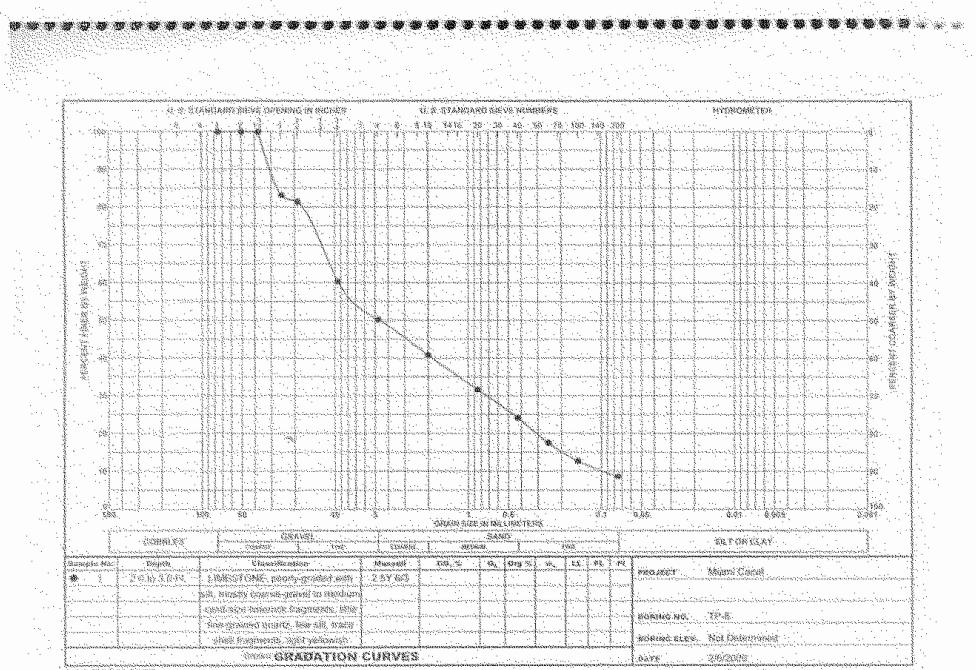

U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
Sample No. | Depth | Classification | Remark | CO3 % | Qu | Dry % | w | LL | PL | PI
B1/S | 2.0 to 2.5 FT | LIMESTONE, poorly-graded with silt, mostly coarse-gravel to medium-sand-size limerock fragments, little fine-grained quartz, few silt, grayish brown (OF-GM)
PROJECT Miami Circle
BORING NO. TP-5
BORING ELEV. Not Determined
DATE 2/6/2005
GRADATION CURVES
SAJ FORM 2087
JAN 93.

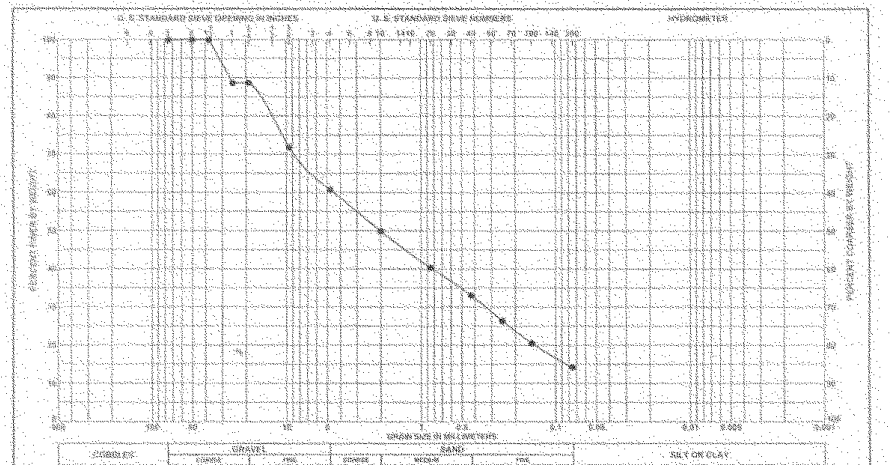


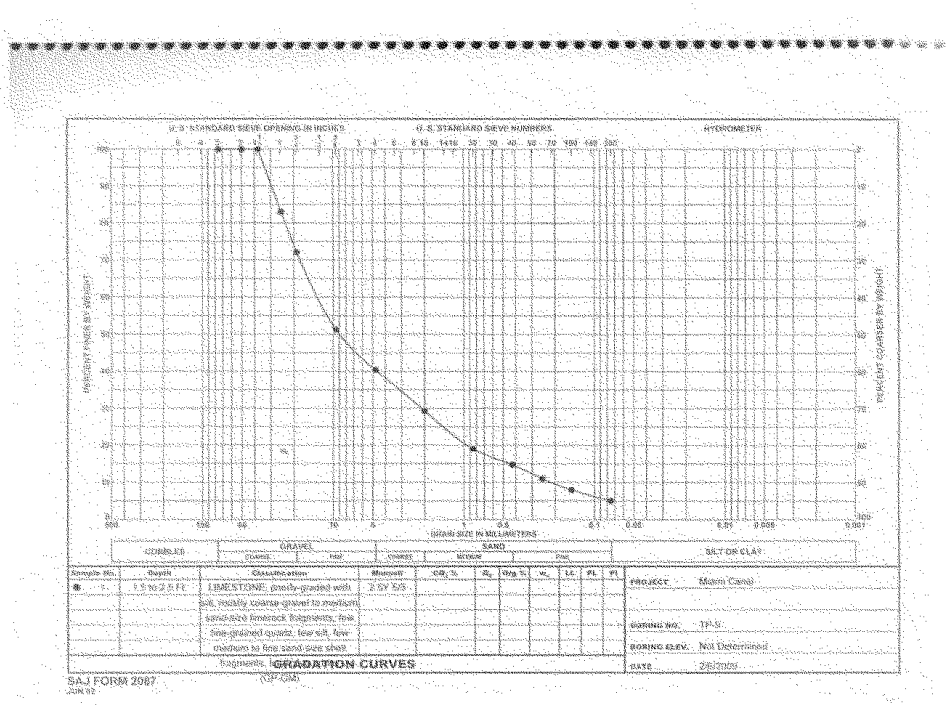
SAJ FORM 2087

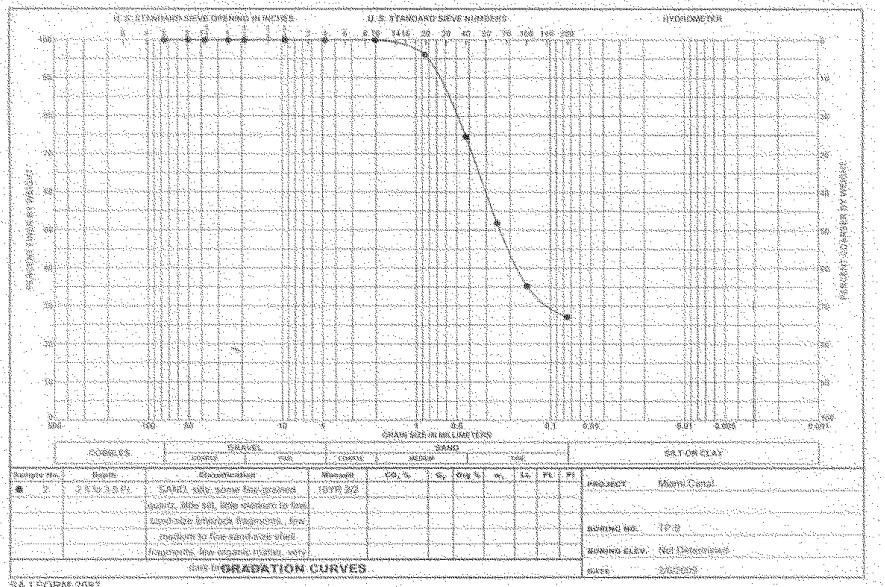

U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
Sample No.
Depth
Classification
Natural
LL
PL
PI
LIMESTONE, silty, marly
2.3 y 3/2
coarse gravel to medium sand size
biotite fragments, little
fine grained quartz, little sil. mica
shell fragments, very dark grained
GRADATION CURVES
PROJECT
Miami Canal
BORING NO.
TP-6
BORING ELEV.
Not Determined
DATE
2/5/2009
SAJ FORM 2087
JAN 92

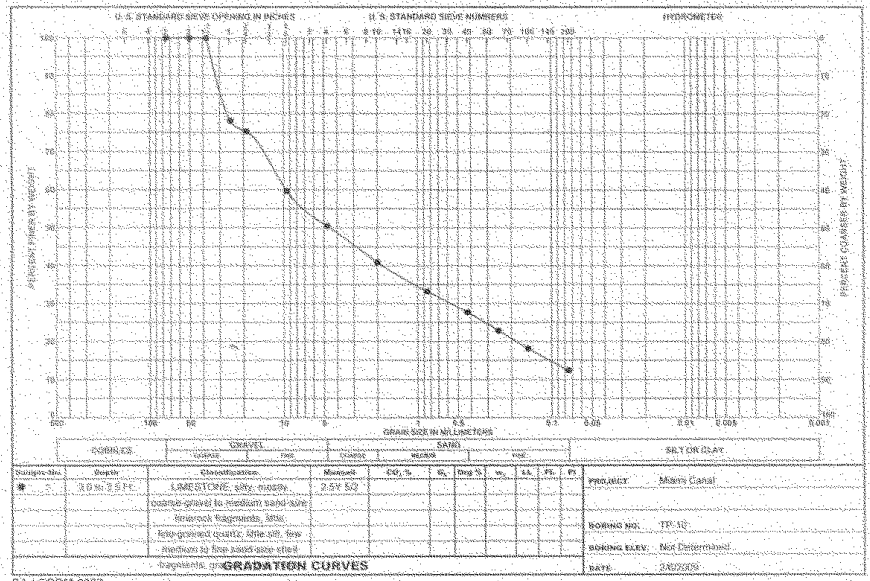

U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
COARSE
FINE
COARSE
MEDIUM
FINE
Sample No. Depth Classification Munsell CO3 % O2 Org % wn LL PL PI
BULK 2.0 to 3.0 Ft SILT, organic-I, some coarse-grained to medium sand-size limestone fragments, few fine-grained quartz sand, very dark grayish brown (OL)
10YR 3/2
PROJECT Miami Canal
BORING NO. TP-7
BORING ELEV. Not Determined
DATE 2/6/2009
GRADATION CURVES
SAJ FORM 2087
JAN 92


U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
Sample No.
Depth
Classification
Natural
LL
PL
PI
PROJECT
Miami Canal
BORING NO.
TP-5
BORING ELEV.
Not Determined
DATE
2/6/2013
GRADATION CURVES
SAJ FORM 2087

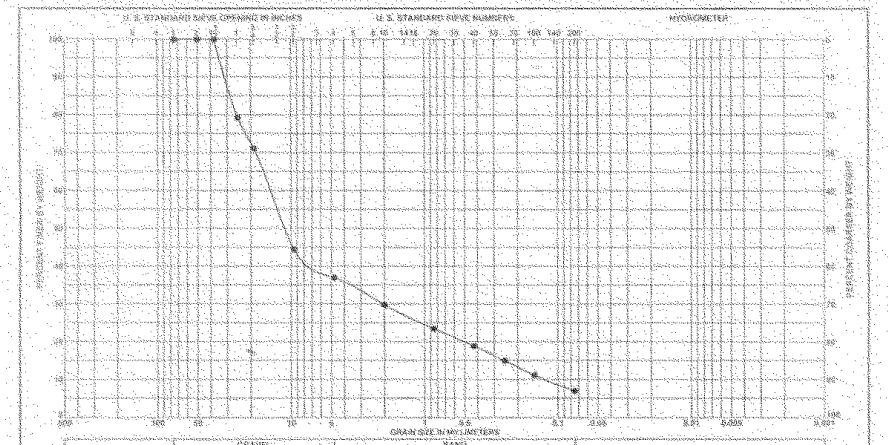

U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
Sample No.
Depth
Classification
Natural
LL
PI
PROJECT
Miami Canal
BORING NO.
TP-8
BORING ELEV.
Not Determined
DATE
GRADATION CURVES
SAJ FORM 2087


U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
Sample No. | Depth | Classification | Symbol | OD, % | S_s | Dia, % | w_n | LL | PL | PI
1 | 1.5 to 2.5 Ft | LIMESTONE, poorly-graded with silt, mostly coarse gravel to medium sand-size limerock fragments, fine sub-rounded quartz, few silt, few medium to fine sand size shell fragments. | SY SS
PROJECT Main Canal
BORING NO. TP-S1
BORING ELEV. Not Determined
DATE 2/6/2009
GRADATION CURVES
SAJ FORM 2087
JUN 92


U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENTAGE FINER BY WEIGHT
PERCENTAGE FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
COARSE
FINE
COARSE
MEDIUM
FINE
Sample No.
Depth
Classification
Moisture
CO3 %
Dry %
LL
PL
PI
SA-1 FORM 2087
GRADATION CURVES
PROJECT
Miami Canal
BORING NO.
TP-3
BORING ELEV.
Not Determined
DATE



SAJ FORM 2087


U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
COARSE
FINE
COARSE
MEDIUM
FINE
Sample No. Depth Classification Moisture CO_3 % O_c Org % w_n LL PL PI
B-2 4.5 to 5.5 ft LIMESTONE, poorly-graded with sand, mostly coarse-grained to medium-grained quartz sand, trace limerock fragments, few fine-grained quartz, few silt, grayish brown (SP-SM) 2.57 SG
GRADATION CURVES
PROJECT Miami Canal
BORING NO. TP-13
BORING ELEV. Not Determined
DATE 2/6/2008
SAJ FORM 2087
JUN 07

ANNEX G-3. GEOLOGICAL INVESTIGATIONS – BLUE, GREEN, AND YELLOW LINES

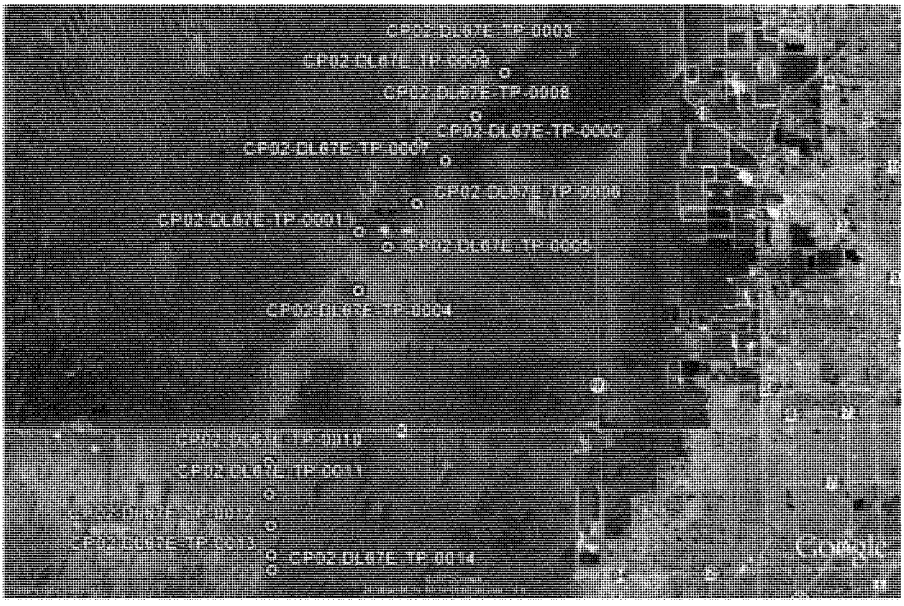


Figure G-3-1. L-67 test pit excavations (U.S. Army Corps of Engineers, 2002)

Boring Designation CP02-DL67E-TP-0001

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
1. PROJECT: US DOI Modified Waters to ENP L-67 Extension		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NGVD29
2. BORING DESIGNATION: CP02-DL67E-TP-0001	LOCATION COORDINATES: X = 781,188 Y = 557,009	11. MANUFACTURER'S DESIGNATION OF DRILL: Backhoe	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAJ	CONTRACTOR FILE NO.	12. TOTAL SAMPLES: 1	DISTURBED: 1 / UNDISTURBED (UD): 0
4. NAME OF DRILLER: H & H Land		13. TOTAL NUMBER CORE BOXES: 0	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL:	BEARING:	14. ELEVATION GROUND WATER: Not Encountered
			15. DATE BORING: STARTED: 06-12-02 / COMPLETED: 06-12-02
6. THICKNESS OF OVERBURDEN: N/A			16. ELEVATION TOP OF BORING: 15.0 Ft.
7. DEPTH DRILLED INTO ROCK: N/A			17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 10.0 Ft.			18. SIGNATURE AND TITLE OF INSPECTOR: Steve Myers, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	NO. REC.	BLOCK OR GRAB NO.	ROD OR CORE NO.	REMARKS	BLOWS/6" OR RUN	RECOVERY
15.0	0.0						15.0		
			FILL: gravelly, mostly subangular to rounded fine to coarse gravel-sized limestone, some subangular to rounded fine to coarse-grained sand-sized carbonate, little silt, few cobble-sized limestone, strong reaction with HCl, moist, gray		1		Test Pit		
5.0	10.0						5.0		
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Laboratory Testing Results: SAMPLE ID: 1 / SAMPLE DEPTH: 0.0/10.0 / LABORATORY CLASSIFICATION: GW-GM*						

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation CP02-DL67E-TP-0001

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
PROJECT: US DOI Modified Waters to ENP	COORDINATE SYSTEM/DATUM: State Plane FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NGVD29
LOCATION COORDINATES: X = 781,188 Y = 557,009	ELEVATION TOP OF BORING: 15.0 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	RQD OR CORE	REMARKS	BLOWS/ 6"/FT	N-VALUE
			*Lab visual classification based on gradation curve. No Atterberg limits.						

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SAJ FORM 1836-A
JUN 02

Boring Designation: CP02-DL67E-TP-0002

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
1. PROJECT: US DOI Modified Waters to ENP: L-67 Extension		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NGVD29
2. BORING DESIGNATION: CP02-DL67E-TP-0002	LOCATION COORDINATES: X = 792,672 Y = 573,643	11. MANUFACTURER'S DESIGNATION OF DRILL: Backhoe	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAJ	CONTRACTOR FILE NO.	12. TOTAL SAMPLES: 1	UNDISTURBED (UD): 0
4. NAME OF DRILLER: H & H Land		13. TOTAL NUMBER CORE BOXES: 0	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL:	BEARING:	14. ELEVATION GROUND WATER: Not Encountered
		15. DATE BORING:	STARTED: 06-12-02 / COMPLETED: 06-12-02
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 15.5 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: N/A	
8. TOTAL DEPTH OF BORING: 10.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Steve Myers, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REF.	BOX OR SAMPLE NO.	ROD CORE UD	REMARKS	BLOWS/6 IN.	MOISTURE
15.5	0.0						15.5		
			FILL, gravelly, mostly fine to coarse gravel-sized limestone, some angular to subangular fine to coarse-grained sand-sized carbonate, little silt, strong reaction with HCl, dry, gray.						
			At El. 11.5 Ft., few cobble-sized limestone		1		Test Pit		
5.5	10.0						5.5		
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Laboratory Testing Results: SAMPLE ID: 1 — SAMPLE DEPTH: 0.0/10.0 — LABORATORY CLASSIFICATION: GP*						

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation CP02-DL67E-TP-0002

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
PROJECT: US DOI Modified Waters to ENP	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NGVD29
LOCATION COORDINATES: X = 792,572 Y = 573,843	ELEVATION TOP OF BORING: 15.5 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	NO. REC.	BOX OR SAMPLE NO.	RQD OR UCS	REMARKS	BLOWS/FT.	N-VALUE
			*Lab visual classification based on gradation curve. No Atterberg limits.						

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SAJ FORM 1836-A
JUN 02

Boring Designation CP02-DL67E-TP-0003

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
1. PROJECT: US DOI Modified Waters to ENP: L-67 Extension		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft)	HORIZONTAL: NAD83 / VERTICAL: NGVD29
2. BORING DESIGNATION: CP02-DL67E-TP-0003	LOCATION COORDINATES: X = 804,064 Y = 550,838	11. MANUFACTURER'S DESIGNATION OF DRILL: Backhoe	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAJ	CONTRACTOR FILE NO.	12. TOTAL SAMPLES: 1	UNDISTURBED (UD): 0
4. NAME OF DRILLER: H & H Land		13. TOTAL NUMBER CORE BOXES: 0	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL:	BEARING:	14. ELEVATION GROUND WATER: Not Encountered
			15. DATE BORING: STARTED 06-12-02 / COMPLETED 06-12-02
6. THICKNESS OF OVERBURDEN: N/A			16. ELEVATION TOP OF BORING: 15.6 Ft.
7. DEPTH DRILLED INTO ROCK: N/A			17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 10.0 Ft.			18. SIGNATURE AND TITLE OF INSPECTOR: Steve Myers, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC	BLOWS/6 IN.	ROD OR CORE	REMARKS	SHEAR
15.6	0.0						15.6	
			FILL, gravelly, mostly subrounded to rounded fine to coarse gravel-sized limestone, little subangular to rounded fine to coarse-grained sand-sized carbonate, little silt, few cobble-sized limestone, moist, gray				Test Pit	
5.6	10.0						5.6	

NOTES:

1. USACE Jacksonville is the custodian for these original files.

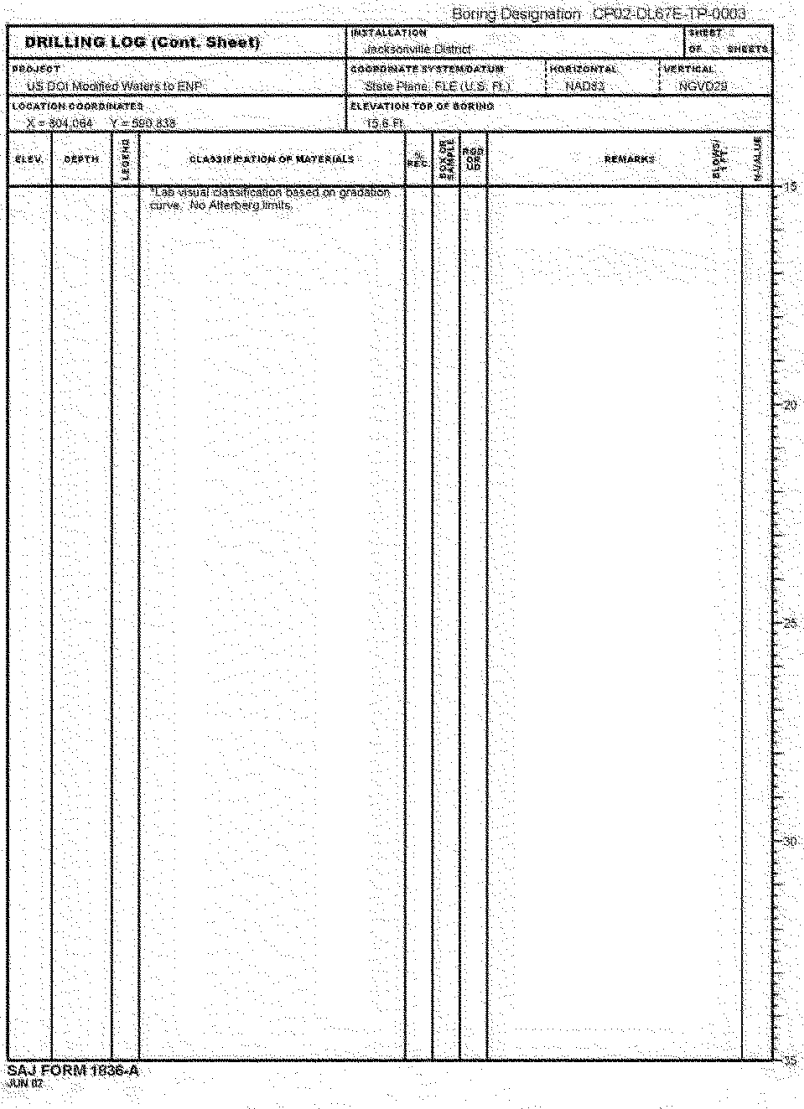
2. Soils are field visually classified in accordance with the Unified Soils Classification System.

3. Laboratory Testing Results:

SAMPLE ID	SAMPLE DEPTH	LABORATORY CLASSIFICATION
1	0.0/10.0	GP-GM*

SAJ FORM 1836
JUN 02

(Continued)



Boring Designation CP02-DL67E-TP-0003

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
PROJECT: US DOI Modified Waters to ENP	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NGVD29
LOCATION COORDINATES: X = 804,064 Y = 560,838	ELEVATION TOP OF BORING: 15.6 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SPOON NO.	CORE RUN	REMARKS	BLOWS/ FT.	N-VALUE
			*Lab visual classification based on gradation curve. No Atterberg limits.						

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SAJ FORM 1836-A
JUN 02

Boring Designation: CP02-DL67E-TP-0004

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
1. PROJECT: US DOI Modified Waters to ENP L-67 Extension		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. FT.)	HORIZONTAL: NAD83 / VERTICAL: NGVD29
2. BORING DESIGNATION: CP02-DL67E-TP-0004	LOCATION COORDINATES: X = 781,054 Y = 545,860	11. MANUFACTURER'S DESIGNATION OF DRILL: Backhoe	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAJ	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED: 2 / UNDISTURBED (UD): 0
4. NAME OF DRILLER: H & H Land		13. TOTAL NUMBER CORE BOXES: 0	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: 6.1 Ft.
			15. DATE BORING: STARTED: 06-19-02 / COMPLETED: 06-19-02
6. THICKNESS OF OVERBURDEN: N/A			16. ELEVATION TOP OF BORING: 10.1 Ft.
7. DEPTH DRILLED INTO ROCK: N/A			17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 10.0 Ft.			18. SIGNATURE AND TITLE OF INSPECTOR: Steve Myers, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	NO.	BOX OR SAMPLE	ROD RUN	REMARKS	BLOWS / 6 IN.	N-VALUE
10.1	0.0						10.1		
			FILL, gravelly, mostly angular to subrounded fine to coarse gravel-sized limestone, some silt, little cobble-sized limestone, few angular to subrounded fine to coarse-grained sand-sized carbonate, strong reaction with HCl, brown		1		Test Pit		
			At El. 6.1 Ft. wet						
4.1	6.0						3.6		
			PEAT, fibrous, black (PT)		2		Test Pit		
0.1	10.0						0.1		
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Laboratory Testing Results: SAMPLE ID: 1 / SAMPLE DEPTH: 0.0/0.5 / LABORATORY CLASSIFICATION: GW*						

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation CP02-DL67E-TP-0004

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
PROJECT: US DOI Modified Waters to EIP	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NGVD29
LOCATION COORDINATES: X = 781,054 Y = 545,860	ELEVATION TOP OF BORING: 10.1 Ft	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC. FT.	BOX OR SAMPLE NO.	PEN. OR RUN	REMARKS	BLOWS/ FOOT	N-VALUE
			*Lab visual classification based on gradation curve. No Atterberg limits.						

SAJ FORM 1836-A
JUN 02

Boring Designation CP02-DL67E-TP-0005

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: OF 2 SHEETS
1. PROJECT: US DOI Modified Waters to ENP L-67 Extension		9. SIZE AND TYPE OF BIT: See Remarks 10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 VERTICAL: NGVD29
2. BORING DESIGNATION: CP02-DL67E-TP-0005 LOCATION COORDINATES: X = 786,627 Y = 554,101		11. MANUFACTURER'S DESIGNATION OF DRILL: Backhoe	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAJ CONTRACTOR FILE NO.		12. TOTAL SAMPLES: 2 DISTURBED: 2 UNDISTURBED (UD): 0	
4. NAME OF DRILLER: H & H Land		13. TOTAL NUMBER CORE BOXES: 0	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED DEG. FROM VERTICAL BEARING		14. ELEVATION GROUND WATER: 3.6 Ft.	
		15. DATE BORING: STARTED 06-19-02, COMPLETED 06-19-02	
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 9.1 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: N/A	
8. TOTAL DEPTH OF BORING: 10.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Steve Myers, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	NO. RECOVERY	BOX OR SAMPLE NO.	ROD OR CORE	REMARKS	SCALE FEET	
9.1	0.0						9.1		0
			FILL, gravelly, mostly angular to subrounded fine to coarse gravel-sized limestone, little silt, few cobble-sized limestone, few subangular to subrounded fine to coarse-grained sand-sized carbonate, brown		1		Test Pit		
			▼ At El. 3.6 Ft., wet						5
2.1	7.0						2.1		
			PEAT, wet, fibrous, black (PT)		2		Test Pit		
-0.9	10.0						-0.9		10
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Laboratory Testing Results: SAMPLE ID: 1; SAMPLE DEPTH: 0.0/7.0; LABORATORY CLASSIFICATION: GP*						15

SAJ FORM 1836
JUN 02

(Continued)

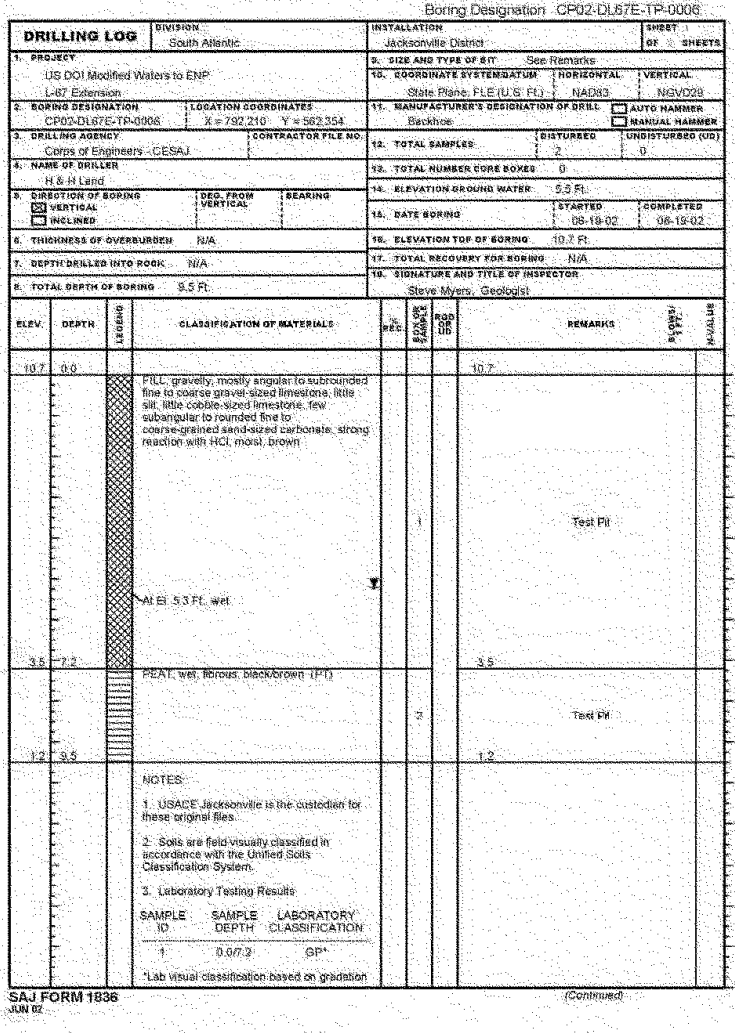
Boring Designation CP02-DL67E-TP-0005

DRILLING LOG (Cont. Sheet)	INSTALLATION Jacksonville District		SHEET OF SHEETS
PROJECT US DOI Modified Waters to ENP	COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.)	HORIZONTAL NAD83	VERTICAL NGVD29
LOCATION COORDINATES X = 786,827 Y = 554,101	ELEVATION TOP OF BORING 9.1 Ft.		

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SPOON SAMPLE NO.	ROD OR CORE NO.	REMARKS	BLOWS/ 6 IN.	N-VALUE
			*Lab visual classification based on gradation curve. No Atterberg limits.						

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SAJ FORM 1836-A
JUN 02



Boring Designation CP02-DL67E-TP-0006

DRILLING LOG

DIVISION	South Atlantic
INSTALLATION	Jacksonville District
SHEET	1 OF 1 SHEETS
1. PROJECT	US DOI Modified Waters to ENP L-67 Extension
2. BORING DESIGNATION	CP02-DL67E-TP-0006
LOCATION COORDINATES	X = 792,210 Y = 562,354
3. DRILLING AGENCY	Corps of Engineers - CESAJ
CONTRACTOR FILE NO.	
4. NAME OF DRILLER	H & H Land
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	N/A
7. DEPTH DRILLED INTO ROCK	N/A
8. TOTAL DEPTH OF BORING	9.5 Ft.
9. SIZE AND TYPE OF BIT	See Remarks
10. COORDINATE SYSTEM/DATUM	State Plane, FLE (U.S. Ft.)
HORIZONTAL	NAD83
VERTICAL	NGVD29
11. MANUFACTURER'S DESIGNATION OF DRILL	Backhoe
☐ AUTO HAMMER ☐ MANUAL HAMMER	
12. TOTAL SAMPLES	DISTURBED 2 UNDISTURBED (UD) 0
12. TOTAL NUMBER CORE BOXES	0
13. ELEVATION GROUND WATER	5.3 Ft.
14. DATE BORING	STARTED 06-19-02 COMPLETED 06-19-02
15. ELEVATION TOP OF BORING	10.7 Ft.
16. TOTAL RECOVERY FOR BORING	N/A
17. SIGNATURE AND TITLE OF INSPECTOR	Steve Myers, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	NO. REC.	NO. OF SAMPLE	ROD OR UD	REMARKS	RECOVERY % (RQD)	BLOW/FT.
10.7	0.0						10.7		
			FILL, gravelly, mostly angular to subrounded fine to coarse gravel-sized limestone, little silt, little cobble-sized limestone, few subangular to rounded fine to coarse-grained sand-sized carbonate, strong reaction with HCl, moist, brown		1		Test Pit		
			At El. 5.3 Ft., wet						
3.5	7.2						3.5		
			PEAT, wet, fibrous, black/brown (PT)		2		Test Pit		
1.2	9.5						1.2		
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Laboratory Testing Results						

SAMPLE ID	SAMPLE DEPTH	LABORATORY CLASSIFICATION
1	0.0/7.2	GP*

*Lab visual classification based on gradation

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation CP02-DL67E-TP-0006

DRILLING LOG (Cont. Sheet)	INSTALLATION Jacksonville District	SHEET OF SHEETS
PROJECT US DOI Modified Waters to ENP	COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.)	HORIZONTAL NAD83 / VERTICAL NGVD29
LOCATION COORDINATES X = 792,210 Y = 562,354	ELEVATION TOP OF BORING 10.7 Ft	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD OR CORE OD	REMARKS	BLOWS/ 6 IN.	MOISTURE
			curve. No Atterberg limits.						

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SAJ FORM 1836-A
JUN 02

Boring Designation CP02-DL67E-TP-0007

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
1. PROJECT: US DOI Modified Waters to ENP; L-67 Extension		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. FT.)	HORIZONTAL: NAD83 / VERTICAL: NGVD29
2. BORING DESIGNATION: CP02-DL67E-TP-0007	LOCATION COORDINATES: X = 797,726 Y = 570,520	11. MANUFACTURER'S DESIGNATION OF DRILL: Backhoe	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAJ	CONTRACTOR FILE NO.	12. TOTAL SAMPLES: DISTURBED: 2 / UNDISTURBED (UD): 0	
4. NAME OF DRILLER: H & H Land		13. TOTAL NUMBER CORE BOXES: 0	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: 3.6 Ft.
			15. DATE BORING: STARTED: 06-19-02 / COMPLETED: 06-19-02
6. THICKNESS OF OVERBURDEN: N/A			16. ELEVATION TOP OF BORING: 9.6 Ft.
7. DEPTH DRILLED INTO ROCK: N/A			17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 10.0 Ft.			18. SIGNATURE AND TITLE OF INSPECTOR: Steve Myers, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD OR CORE	REMARKS	BLOWS/FT.	N-VALUE
9.6	0.0		FILL, gravelly, mostly angular to subrounded fine to coarse gravel-sized limestone, little cobble-sized limestone, little silt, few fine to coarse-grained sand-sized carbonate, strong reaction with HCl, dry, brown.				9.6		
			At El. 5.6 Ft., gray		1		Test Pit		
			At El. 3.6 Ft., wet						
1.4	8.2		PEAT, wet, fibrous, black/brown (PT)		2		1.4 Test Pit		
-0.4	10.0						-0.4		

NOTES:

1. USACE Jacksonville is the custodian for these original files.

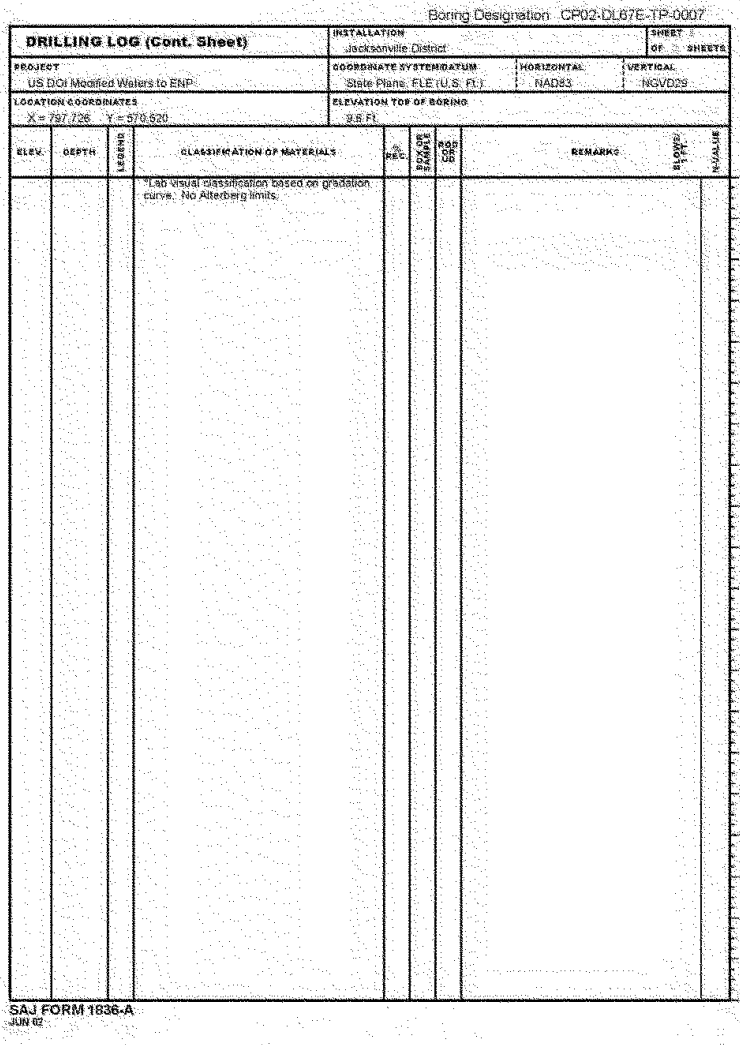
2. Soils are field visually classified in accordance with the Unified Soils Classification System.

3. Laboratory Testing Results:

SAMPLE ID	SAMPLE DEPTH	LABORATORY CLASSIFICATION
1	0.0/8.2	GP-GM*

SAJ FORM 1836
JUN 02

(Continued)



Boring Designation CP02-DL67E-TP-0007

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
PROJECT: US DOI Modified Waters to ENP	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NGVD29	
LOCATION COORDINATES: X = 797,726 Y = 570,920	ELEVATION TOP OF BORING: 9.6 Ft	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX OR SAMPLE NO.	PID OR OVA	REMARKS	BLOWS/ 1 FT.	N-VALUE
			*Lab visual classification based on gradation curve. No Atterberg limits.						

SAJ FORM 1836-A
JUN 02

Boring Designation CP02-DL67E-TP-0008

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville Distrct	SHEET 1 OF 1 SHEETS
1. PROJECT: US DOI Modified Waters to ENP L-67 Extension		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NGVD29
2. BORING DESIGNATION: CP02-DL67E-TP-0008	LOCATION COORDINATES: X = 803,486 Y = 579,032	11. MANUFACTURER'S DESIGNATION OF DRILL: Backhoe	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAJ	CONTRACTOR FILE NO.	12. TOTAL SAMPLES: DISTURBED 3 / UNDISTURBED (UD) 0	
4. NAME OF DRILLER: H & H Land		13. TOTAL NUMBER CORE BOXES: 0	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: 4.7 Ft.
			15. DATE BORING: STARTED 06-20-02 / COMPLETED 06-20-02
6. THICKNESS OF OVERBURDEN: N/A			16. ELEVATION TOP OF BORING: 10.2 Ft.
7. DEPTH DRILLED INTO ROCK: N/A			17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 9.0 Ft.			18. SIGNATURE AND TITLE OF INSPECTOR: Steve Myers, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	NO. REC.	BOX OR CORE NO.	ROD OR UD	REMARKS	BLOWS/ FT.	HP/ATTER
10.2	0.0						10.2		
			FILL, cobbles, mostly angular cobble-sized limestone, little silt, few sand, strong reaction with HCl, dry, gray						
					1		Test Pit		
			At El. 5.2 Ft., gravelly, some coarse gravel-sized limestone, little cobble-sized limestone At El. 4.7 Ft., wet						
2.7	7.5						2.7		
			PEAT, high plasticity, soft, fibrous, interbedded with lean clay, black (PT)		2		Test Pit		
1.2	9.0						1.2		
			BORING TERMINATED IN REFUSAL						
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System. 3. Laboratory Testing Results: SAMPLE ID: 1 — SAMPLE DEPTH: 0.0/7.5 — LABORATORY CLASSIFICATION: GW* *Lab visual classification based on gradation curve. No Atterberg limits.						

SAJ FORM 1836
JUN 02

Boring Designation CP02-DL67E-TP-0009

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 1 SHEETS
1. PROJECT: US DOI Modified Waters to ENP L-67 Extension		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NGVD29
2. BORING DESIGNATION: CP02-DL67E-TP-0009	LOCATION COORDINATES: X = 809,983 Y = 587,280	11. MANUFACTURER'S DESIGNATION OF DRILL: Backhoe	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAJ	CONTRACTOR FILE NO.:	12. TOTAL SAMPLES: 2	DISTURBED: 2 / UNDISTURBED (UD): 0
4. NAME OF DRILLER: H & H Land		13. TOTAL NUMBER CORE BOXES: 0	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL:	BEARING:	14. ELEVATION GROUND WATER: 4.6 Ft.
		15. DATE BORING	STARTED: 08-20-02 / COMPLETED: 08-20-02
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 10.0 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: N/A	
8. TOTAL DEPTH OF BORING: 9.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Steve Myers, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX NO. OR SAMPLE NO.	CORE OR UD	REMARKS	STRATA CHANGE	WATER LEVEL
10.0	0.0						10.0		
			FILL: gravelly, mostly angular to subrounded fine to coarse gravel-sized limestone, little silt, few fine to coarse gravel-sized limestone, moist, brown		1		Test Pit		
			ALEI: 4.6 Ft. wet						
2.2	7.8						2.2		
			PEAT: fibrous, black/brown (PT)		2		Test Pit		
1.0	9.0						1.0		
			BORING TERMINATED IN REFUSAL						

NOTES:

1. USACE Jacksonville is the custodian for these original files.
2. Soils are field visually classified in accordance with the Unified Soils Classification System.
3. Laboratory Testing Results:

SAMPLE ID	SAMPLE DEPTH	LABORATORY CLASSIFICATION
1	0.0/7.8	GW*

*Lab visual classification based on gradation curve. No Atterberg limits.

SAJ FORM 1836
JUN 02

Boring Designation: CP02-DL67E-TP-0010

DRILLING LOG

DIVISION: South Atlantic		INSTALLATION: Jacksonville District	SHEET 1 OF 1 SHEETS
1. PROJECT: US DOI Modified Waters to ENP L-67 Extension		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NGVD29
2. BORING DESIGNATION: CP02-DL67E-TP-0010	LOCATION COORDINATES: X = 783,742 Y = 513,043	11. MANUFACTURER'S DESIGNATION OF DRILL: Backhoe	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAJ	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED: 1 / UNDISTURBED (UD): 0
4. NAME OF DRILLER: H & H Land		13. TOTAL NUMBER CORE BOXES: 0	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL / BEARING	14. ELEVATION GROUND WATER: 3.3 Ft.	
		15. DATE BORING	STARTED: 08-11-02 / COMPLETED: 08-11-02
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 13.0 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: N/A	
8. TOTAL DEPTH OF BORING: 10.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Steve Myers, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR PENET.	POCKET PEN. OR UCS	REMARKS	BLOWS/ 6 IN.	HAMMER
13.0	0.0						13.0		
			FILL, sandy, some angular to subrounded fine to coarse grained sand-sized carbonate, some gravel to boulder-sized limestone up to 3', little rounded fine-grained sand-sized quartz, little silt, dry, tan		1		Test Pit		
3.7	9.3						3.7		
3.5	9.5		PEAT, moist, fibrous, black (PT)						
3.0	10.0		LIMESTONE, hard, moderately weathered, aphanitic, vuggy, brown/tan				3.0		

NOTES:

1. USACE Jacksonville is the custodian for these original files.

2. Soils are field visually classified in accordance with the Unified Soils Classification System.

3. Laboratory Testing Results:

SAMPLE ID	SAMPLE DEPTH	LABORATORY CLASSIFICATION
1	0.0/9.3	SP*

Abbreviations:
NR = Not Recorded

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation CP02-DL67E-TP-0010

DRILLING LOG (Cont. Sheet)	INSTALLATION Jacksonville District	SHEET 1 OF 1 SHEETS
PROJECT US DOI Modified Waters to ENP	COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.)	HORIZONTAL NAD83 / VERTICAL NGVD29
LOCATION COORDINATES X = 793,742 Y = 513,043	ELEVATION TOP OF BORING 13.0 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC. FT.	BOX OR SAMPLE NO.	RQD OR CORE	REMARKS	BLOWS/ FT.	N-VALUE
			*Lab visual classification based on gradation curve. No Atterberg limits.						

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SAJ FORM 1836-A
JUN 02

Boring Designation CP02-DL67E-TP-0011

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District
	SHEET 1 OF SHEETS
1. PROJECT: US DOI Modified Waters to ENP L-67 Extension	9. SIZE AND TYPE OF BIT: See Remarks
	10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NGVD29
2. BORING DESIGNATION: CP02-DL67E-TP-0011 / LOCATION COORDINATES: X = 783,955 Y = 507,074	11. MANUFACTURER'S DESIGNATION OF DRILL: Backhoe ☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAJ / CONTRACTOR FILE NO.	12. TOTAL SAMPLES: DISTURBED 2 / UNDISTURBED (UD) 0
4. NAME OF DRILLER: H & H Land	13. TOTAL NUMBER CORE BOXES: 0
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED / DEG. FROM VERTICAL / BEARING	14. ELEVATION GROUND WATER: 3.1 Ft.
	15. DATE BORING: STARTED 06-11-02 / COMPLETED 06-11-02
6. THICKNESS OF OVERBURDEN: N/A	16. ELEVATION TOP OF BORING: 12.3 Ft.
7. DEPTH DRILLED INTO ROCK: N/A	17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 10.0 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: Steve Myers, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX OR SAMPLE NO.	RQD OR UD	REMARKS	BLOWS/6 IN.	SPT N-VALUE
12.3	0.0		FILL, sandy, mostly rounded fine-grained sand-sized quartz, little subangular to rounded carbonate, little silt, few fine to coarse gravel-sized limestone, few cobble-sized limestone, strong reaction with HCl, moist, tan		1		12.3 Test Pit		
4.6	7.8		PEAT, few clay, black (PT)				4.6 Test Pit		
4.3	8.0		SAND, clayey, medium plasticity, soft, some rounded fine-grained sand-sized quartz, some clay, little silt, wet, gray (SC)		2		Test Pit		
2.5	9.8		LIMESTONE, hard, slightly weathered, aphanitic, vuggy, brown				2.5 Test Pit		

NOTES:

1. USACE Jacksonville is the custodian for these original files.

2. Soils are field visually classified in accordance with the Unified Soils Classification System.

3. Laboratory Testing Results

SAMPLE ID	SAMPLE DEPTH	LABORATORY CLASSIFICATION

SAJ FORM 1836
JUN 82

(Continued)

Boring Designation CP02-DL67E-TP-0011

DRILLING LOG (Cont. Sheet)

INSTALLATION	SHEET	OF	SHEETS
Jacksonville District			

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
US DOI Modified Waters to ENP	State Plane, FLE (U.S. Ft.)	NAD83	NGVD29

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 783,955 Y = 507,074	12.3 Ft

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	RQD OR CORE	REMARKS	BLOWS/ 1 FT.	N-VALUE
			1 0.0/7.8 SP*						
			*Lab visual classification based on gradation curve. No Atterberg limits.						

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SAJ FORM 1836-A
JUN 02

Boring Designation CP02-DL67E-TP-0012

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 1 SHEETS
1. PROJECT: US DOI Modified Waters to ENP L-67 Extension		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NGVD29
2. BORING DESIGNATION: CP02-DL67E-TP-0012	LOCATION COORDINATES: X = 784,168 Y = 501,106	11. MANUFACTURER'S DESIGNATION OF DRILL: Backhoe	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAJ	CONTRACTOR FILE NO.	12. TOTAL SAMPLES: DISTURBED 1	UNDISTURBED (UD) 0
4. NAME OF DRILLER: H & H Land		13. TOTAL NUMBER CORE BOXES: 0	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: 3.6 Ft.
		15. DATE BORING: STARTED 06-11-02	COMPLETED 06-11-02
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 12.3 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: N/A	
8. TOTAL DEPTH OF BORING: 10.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Steve Myers, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	NO. REC.	BLOWS/6 IN OR BLOWS/FT.	ROD OR UD	REMARKS	BLOWS/FT.	N-VALUE
12.3	0.0						12.3		
			FILL, sandy, mostly rounded fine-grained sand-sized quartz, little subangular to rounded fine to coarse-grained sand-sized carbonate, few gravel to cobble-sized limestone, strong reaction with HCl, moist, tan	1			Test Pit		
			At El. 3.8 Ft., few silt, wet, gray ▼						
2.8	9.5						2.8		
2.3	10.0		LIMESTONE, hard, slightly weathered, aphanitic, solid, yellowish				2.3 Test Pit		

NOTES:

1. USACE Jacksonville is the custodian for these original files.
2. Soils are field visually classified in accordance with the Unified Soils Classification System.
3. Laboratory Testing Results

SAMPLE ID	SAMPLE DEPTH	LABORATORY CLASSIFICATION
1	0.0/9.5	SP*

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation CP02-DL67E-TP-0012

DRILLING LOG (Cont. Sheet)	INSTALLATION Jacksonville District	SHEET OF SHEETS
PROJECT US DOI Modified Waters to ENP	COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.)	HORIZONTAL NAD83 / VERTICAL NGVD29
LOCATION COORDINATES X = 784,168 Y = 501,106	ELEVATION TOP OF BORING 12.3 Ft	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD OR CORE	REMARKS	BLOWS/ 1 FT.	N-VALUE
			*Lab visual classification based on gradation curve. No Atterberg limits.						

SAJ FORM 1836-A
JUN 02

Boring Designation: CP02-DL67E-TP-0013

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 1 SHEETS
1. PROJECT: US DOI Modified Waters to ENP L-67 Extension		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NGVD29
2. BORING DESIGNATION: CP02-DL67E-TP-0013	LOCATION COORDINATES: X = 784,371 Y = 495,427	11. MANUFACTURER'S DESIGNATION OF DRILL: Backhoe	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAJ	CONTRACTOR FILE NO.	12. TOTAL SAMPLES: DISTURBED 2 / UNDISTURBED (UD) 0	
4. NAME OF DRILLER: H & H Land		13. TOTAL NUMBER CORE BOXES: 0	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: 1.7 Ft.
			15. DATE BORING: STARTED 06-11-02 / COMPLETED 06-11-02
6. THICKNESS OF OVERBURDEN: N/A			16. ELEVATION TOP OF BORING: 11.4 Ft.
7. DEPTH DRILLED INTO ROCK: N/A			17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 10.0 Ft.			18. SIGNATURE AND TITLE OF INSPECTOR: Steve Myers, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX OR SAMPLE NO.	ROD OR UD	REMARKS	BLOWS/6 IN.	N-VALUE
11.4	0.0		FILL, sandy, mostly rounded fine-grained sand-sized quartz, some subrounded to rounded fine-grained sand-sized carbonate, little coarse gravel-sized limestone, few cobble-sized limestone, moist, light gray		1		11.4 Test Pit		
5.4	6.0		PEAT, moist, fibrous, black (PT)		2		5.4 Test Pit		
1.4	10.0		At El. 1.7 Ft. wet BORING TERMINATED IN REFUSAL				1.4		

NOTES:

1. USACE Jacksonville is the custodian for these original files.

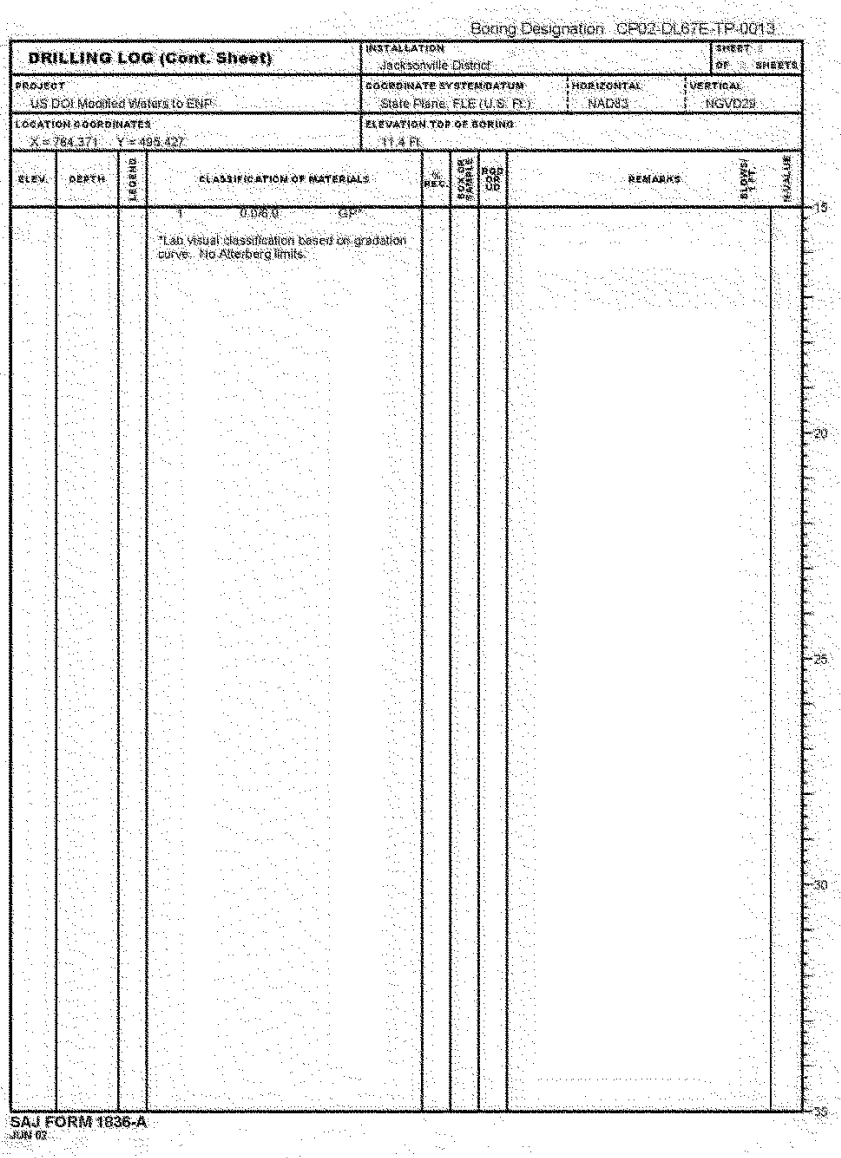
2. Soils are field visually classified in accordance with the Unified Soils Classification System.

3. Laboratory Testing Results:

SAMPLE ID	SAMPLE DEPTH	LABORATORY CLASSIFICATION

SAJ FORM 1836
JUN 02

(Continued)



Boring Designation CP02-DL67E-TP-0013

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
PROJECT: US DOI Modified Waters to ENP	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. FT.)	HORIZONTAL: NAD83 / VERTICAL: NGVD29
LOCATION COORDINATES: X = 784,371 Y = 495,427	ELEVATION TOP OF BORING: 11.4 FT.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	RQD OR CORE	REMARKS	BLOWS/ 6 IN.	N-VALUE
			1 0.0/6.0 GP*						
			*Lab visual classification based on gradation curve. No Atterberg limits.						

15
20
25
30
35

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Boring Designation CP02-DL67E-TP-0014

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District		SHEET 1 OF 1 SHEETS
1. PROJECT: US DOI Modified Waters to ENP L-67 Extension	9. SIZE AND TYPE OF BIT: See Remarks		
	10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83	VERTICAL: NGVD29
2. BORING DESIGNATION: CP02-DL67E-TP-0014	LOCATION COORDINATES: X = 764,470 Y = 492,583	11. MANUFACTURER'S DESIGNATION OF DRILL: Backhoe	☐ AUTO HAMMER ☐ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAJ	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED: 1 UNDISTURBED (UD): 0
4. NAME OF DRILLER: H & H Land		13. TOTAL NUMBER CORE BOXES: 0	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: 2.6 Ft.
			15. DATE BORING: STARTED 06-11-02 COMPLETED 06-11-02
6. THICKNESS OF OVERBURDEN: N/A			16. ELEVATION TOP OF BORING: 11.4 Ft.
7. DEPTH DRILLED INTO ROCK: N/A			17. TOTAL RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING: 9.3 Ft.			18. SIGNATURE AND TITLE OF INSPECTOR: Steve Myers, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD OR UD	REMARKS	BLOWS/FT.	PEN./REC.
11.4	0.0						11.4		
			FILL, sandy, mostly rounded fine-grained sand-sized quartz, few angular to subrounded fine-grained sand-sized carbonate, few fine gravel-sized limestone, strong reaction with HCl, moist, tan		1		Test Pit		
			*At El. 5.4 Ft., little cobble-sized limestone						
4.2	7.3		PEAT, wet, brown/black, (PT)				4.2 Test Pit		
2.2	9.3		BORING TERMINATED IN REFUSAL				2.2		

NOTES:

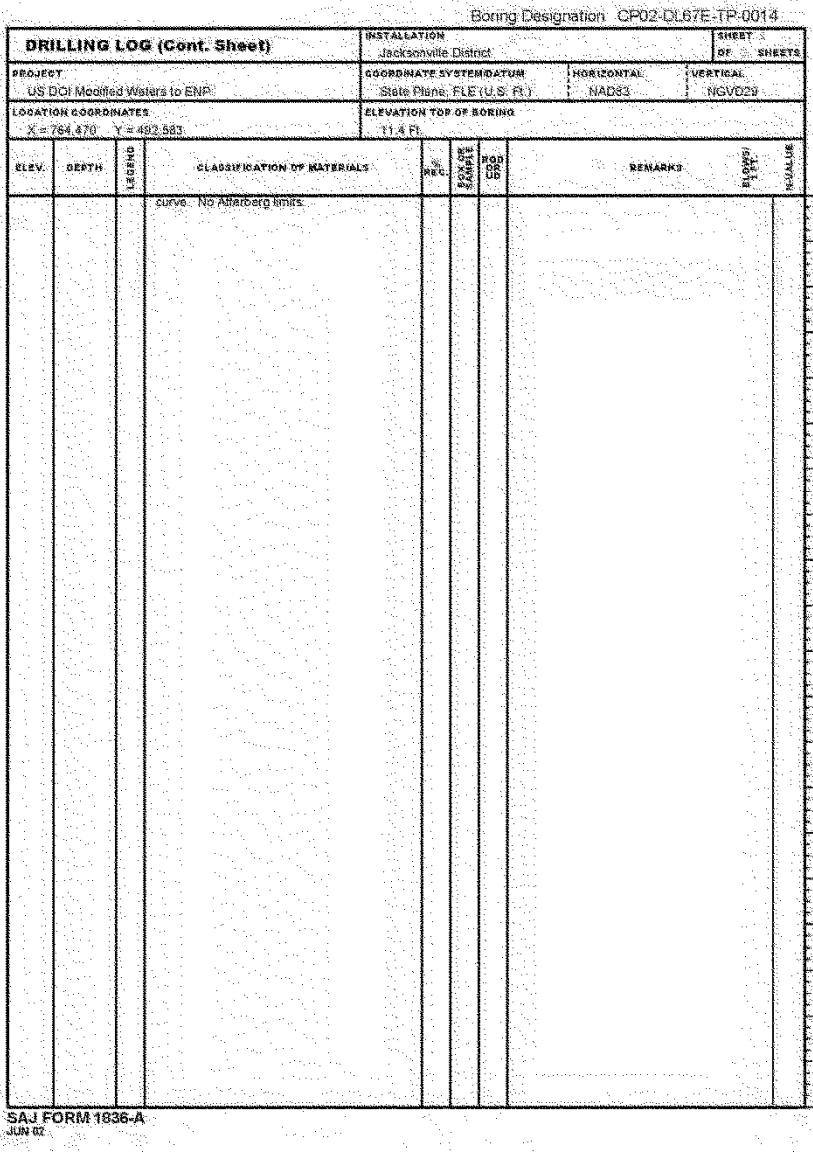
1. USACE Jacksonville is the custodian for these original files.
2. Soils are field visually classified in accordance with the Unified Soils Classification System.
3. Laboratory Testing Results:

SAMPLE ID	SAMPLE DEPTH	LABORATORY CLASSIFICATION
1	0.0/7.3	SP*

*Lab visual classification based on gradation.

SAJ FORM 1836
JUN 02

(Continued)



Boring Designation CP02-DL67E-TP-0014

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET: OF SHEETS
PROJECT: US DOI Modified Waters to ENP	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NGVD29
LOCATION COORDINATES: X = 764,470 Y = 492,583	ELEVATION TOP OF BORING: 11.4 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	SAMPLE NUMBER & TYPE	ROD OR CORE	REMARKS	BLOWS/6 IN.	N-VALUE
			curve. No Atterberg limits.						

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Figure G-3-2. L-67C Boring Map (U.S. Army Corps of Engineers, 2009)

Boring Designation CP09-DCOMP-CB-0001

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 1 SHEETS
1. PROJECT: C&SF:CERP:WCA 3 Decomp Part 1 L-67A Vicinity		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. FT.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP09-DCOMP-CB-0001	LOCATION COORDINATES: X = Y =	11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAM	CONTRACTOR FILE NO.	12. TOTAL SAMPLES: DISTURBED 12 / UNDISTURBED (UD) 0	
4. NAME OF DRILLER: C. Brown		13. TOTAL NUMBER CORE BOXES: 1	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL:	BEARING:	14. ELEVATION GROUND WATER: 9.1 Ft.
		15. DATE BORING: STARTED 07-01-09 / COMPLETED 07-01-09	
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 16.3 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: 56 %	
8. TOTAL DEPTH OF BORING: 17.6 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Jarrell Hand, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	NO. REC.	BOX OR SAMPLE	ROD OR UD	REMARKS	BLOWS / 6 IN.	N-VALUE
16.3	0.0						16.3		
			FILL, gravelly, few fine to coarse-grained, sand-sized carbonate, few silt, trace organic matter, moist, 10YR 6/2 light brownish gray	67	1		SPT Sampler 14.8	8 12 8	20
				53	2		SPT Sampler 13.3	5 5 8	13
				40	3		SPT Sampler 11.8	6 3 6	9
				47	4		SPT Sampler 10.3	1 2 5	7
			▼	47	5		SPT Sampler 8.8	1 1 2	3
7.3	9.0			47	6		SPT Sampler 7.3	3 5 8	13
			SILT, organic-L, few peat, slightly fibrous, 10YR 2/1 black (OL)	80	7		SPT Sampler 5.8	2 2 5	7
				67	8		SPT Sampler 4.3	2 10 8	18
				40	9		SPT Sampler 3.8	1	
							Advanced Boring 2.8		
				80	10		SPT Sampler 1.3	2 3 3	6

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JUN 02

(Continued)

Boring Designation CP09-DCOMP-CB-0001

DRILLING LOG (Cont. Sheet)	INSTALLATION Jacksonville District	SHEET 4 OF 4 SHEETS
PROJECT C&SF CERP WCA 3 Decomp Part 1	COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.)	HORIZONTAL NAD83 / VERTICAL NAVD88
LOCATION COORDINATES X = Y =	ELEVATION TOP OF BORING 16.3 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BLOCK OR SHELBY NO.	ROD OR CORE	REMARKS	BLOWS/0.5 FT.	N-VALUE
1.2	15.3		LIMESTONE, hard, slightly weathered, fine grained, 2.5YR 6/2 pale red	67	11		SPT Sampler	6 10 20	30
1.3	17.6			45	12		SPT Sampler -1.3	9 0	

NOTES:

1. USACE Jacksonville is the custodian for these original files.

2. Soils are field visually classified in accordance with the Unified Soils Classification System.

3. Laboratory Testing Results

SAMPLE ID	SAMPLE DEPTH	LABORATORY CLASSIFICATION
1	0.0/1.5	GP-GM*
4	4.5/6.0	GM*

*Lab visual classification based on gradation curve. No Atterberg limits.

4. Additional Laboratory Testing

2 Moisture Content
5D Moisture Content
9 Moisture Content
13 Moisture Content

140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.)

SAJ FORM 1836-A
JUN 02

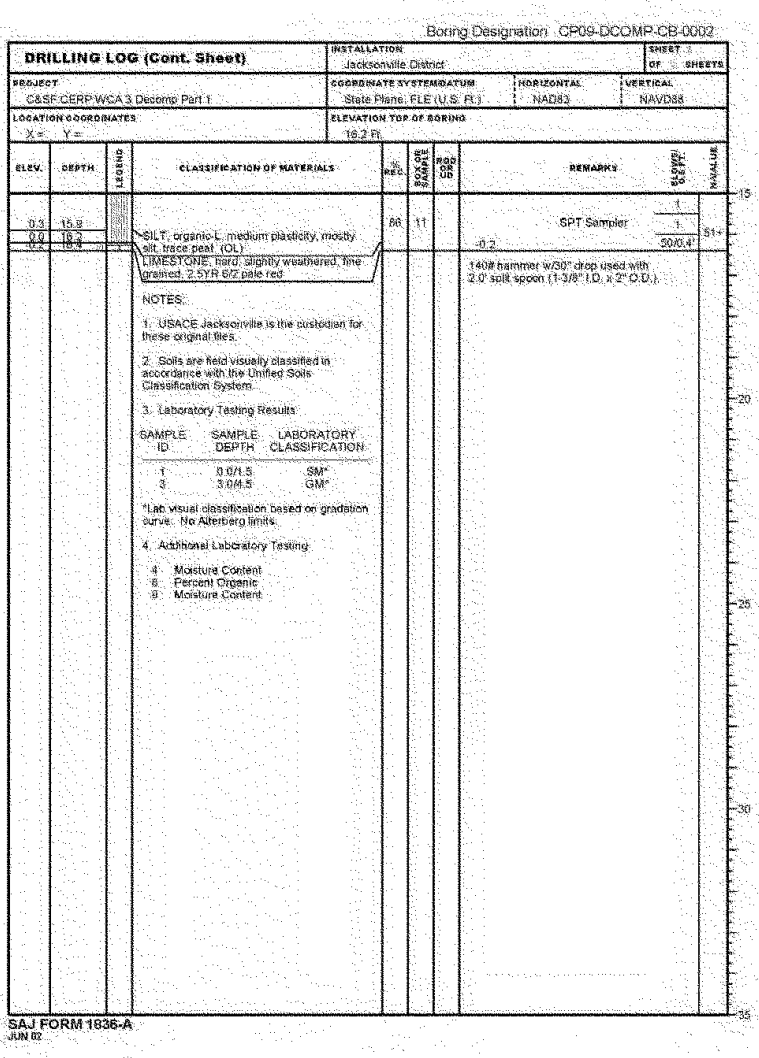
Boring Designation CP09-DCOMP-CB-0002

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 1 SHEETS
1. PROJECT: C&SF CERP WCA 3 Decomp Part 1 L-67A Vicinity		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 VERTICAL: NAVD88
2. BORING DESIGNATION: CP09-DCOMP-CB-0002	LOCATION COORDINATES: X = Y =	11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAM	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED: 11 UNDISTURBED (UD): 0
4. NAME OF DRILLER: C. Brown		13. TOTAL NUMBER CORE BOXES: 1	
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: 9.7 Ft.
		15. DATE BORING	STARTED: 07-01-09 COMPLETED: 07-01-09
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 16.2 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: 51 %	
8. TOTAL DEPTH OF BORING: 16.4 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Jerrell Hand, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX OR SAMPLE NO.	POCKET PEN. OR TOR.	REMARKS	BLOWS/6" OR RQD	N-VALUE
16.2	0.0						16.2		
			FILL, gravelly, mostly carbonate, few fine to coarse-grained sand-sized carbonate, few silt, trace organic matter, moist, many hard carbonate cobles and boulders too large to sample at surface, 10YR 7/1 light gray	67	1		SPT Sampler 14.7	3 8 8	16
				47	2		SPT Sampler 13.2	7 7 0	7
				87	3		SPT Sampler 11.7	8 4 5	9
				33	4		SPT Sampler 10.2	2 10 6	16
				47	5		SPT Sampler 8.7	25 6 14	20
8.7	7.5		SILT, organic-L, few peat, wet, slightly fibrous, 10YR 2/1 black (OL)	60	6		SPT Sampler 7.2	2 3 4	7
				20	7		SPT Sampler 5.7	3 1 1	2
				33	8		SPT Sampler 4.2	3 4 6	10
				27	9		SPT Sampler 2.7	1 1 1	2
				80	10		SPT Sampler 1.3	1 1 3	4

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(Continued)



Boring Designation: CP09-DCOMP-CB-0002

DRILLING LOG (Cont. Sheet)

INSTALLATION: Jacksonville District			SHEET 1 OF 1 SHEETS
PROJECT: C&SF CERP WCA 3 Decomp Part 1	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83	VERTICAL: NAVD88
LOCATION COORDINATES: X = Y =	ELEVATION TOP OF BORING: 16.2 Ft		

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX OR SAMPLE NO.	ROD LOSS	REMARKS	BLOWS PER 6 INCH	N-VALUE
16.2	0.0								
0.3	15.9		SILT, organic-L, medium plasticity, mostly silt, trace peat (OL)	86	11		SPT Sampler	1	
0.0	16.2		LIMESTONE, hard, slightly weathered, fine grained, 2.5YR 6/2 pale red					1	51+
-0.2	16.4						-0.2	50/0.4"	

NOTES:

1. USACE Jacksonville is the custodian for these original files.

2. Soils are field visually classified in accordance with the Unified Soils Classification System.

3. Laboratory Testing Results

SAMPLE ID	SAMPLE DEPTH	LABORATORY CLASSIFICATION
1	0.0/1.5	SM*
3	3.0/4.5	GM*

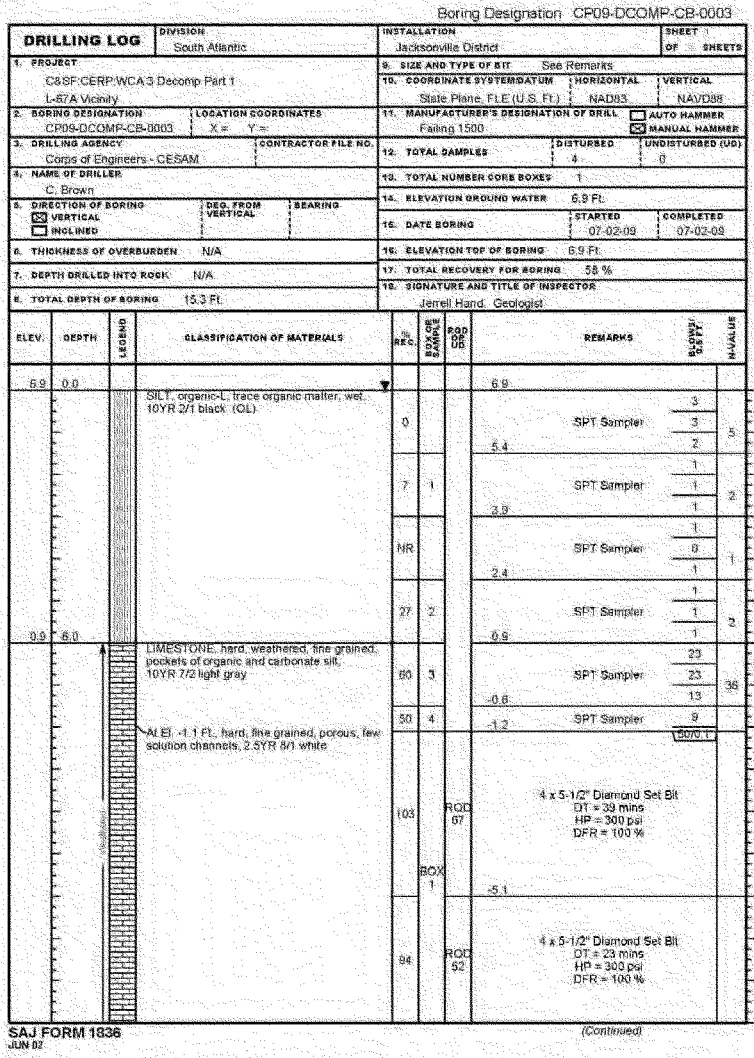
*Lab visual classification based on gradation curve. No Alterberg limits.

4. Additional Laboratory Testing

4 Moisture Content
8 Percent Organic
9 Moisture Content

140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.).

SAJ FORM 1836-A
JUN 02



Boring Designation CP09-DCOMP-CB-0003

DRILLING LOG

DIVISION	South Atlantic
INSTALLATION	Jacksonville District
SHEET	1 OF SHEETS
1. PROJECT	C&SF:CERP:WCA 3 Decomp Part 1 L-67A Vicinity
2. BORING DESIGNATION	CP09-DCOMP-CB-0003
LOCATION COORDINATES	X = Y =
3. DRILLING AGENCY	Corps of Engineers - CESAM
CONTRACTOR FILE NO.	
4. NAME OF DRILLER	C. Brown
5. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED
DEG. FROM VERTICAL	
BEARING	
6. THICKNESS OF OVERBURDEN	N/A
7. DEPTH DRILLED INTO ROCK	N/A
8. TOTAL DEPTH OF BORING	15.3 Ft.
9. SIZE AND TYPE OF BIT	See Remarks
10. COORDINATE SYSTEM/DATUM	State Plane, FLE (U.S. Ft.)
HORIZONTAL	NAD83
VERTICAL	NAVD88
11. MANUFACTURER'S DESIGNATION OF DRILL	Failing 1500
☐ AUTO HAMMER ☒ MANUAL HAMMER	
12. TOTAL SAMPLES	4
DISTURBED	4
UNDISTURBED (UD)	0
13. TOTAL NUMBER CORE BOXES	1
14. ELEVATION GROUND WATER	6.9 Ft.
15. DATE BORING	STARTED 07-02-09
COMPLETED	07-02-09
16. ELEVATION TOP OF BORING	6.9 Ft.
17. TOTAL RECOVERY FOR BORING	58 %
18. SIGNATURE AND TITLE OF INSPECTOR	Jerrell Hand, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE #	ROD OR UD	REMARKS	BLOWS/6 IN.	N-VALUE
6.9	0.0						6.9		
			SILT, organic-L, trace organic matter, wet, 10YR 2/1 black (OL)	0			SPT Sampler	3 3 2	5
							5.4		
				7	1		SPT Sampler	1 1 1	2
							3.9		
				NR			SPT Sampler	1 0 1	1
							2.4		
				27	2		SPT Sampler	1 1 1	2
0.9	6.0						0.9		
			LIMESTONE, hard, weathered, fine grained, pockets of organic and carbonate silt, 10YR 7/2 light gray	60	3		SPT Sampler	23 23 13	36
				50	4		SPT Sampler	9 50/0.1	
							-1.2		
			At El. -1.1 Ft., hard, fine grained, porous, few solution channels, 2.5YR 8/1 white	103	BOX 1	ROD 67	4 x 5-1/2" Diamond Set Bit DT = 39 mins HP = 300 psi DFR = 100 %		
							-5.1		
				94		ROD 52	4 x 5-1/2" Diamond Set Bit DT = 23 mins HP = 300 psi DFR = 100 %		

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation CP09-DCOMP-CB-0003

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET OF SHEETS
PROJECT: CBSF CERP WCA 3 Decomp Part 1	COORDINATE SYSTEM/DATUM: State Plane: FLE (U.S. FT)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = Y =	ELEVATION TOP OF BORING: 8.9 Ft	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	RECOVERED SAMPLE	ROD DROP	REMARKS	BLOWS/6 INCH	N-VALUE
-6.4	15.3			94			-6.4		

NOTES:

1. USACE Jacksonville is the custodian for these original files.

2. Soils are field visually classified in accordance with the Unified Soils Classification System.

3. At -5 Ft. above water level, water was flowing from NW side of levee through gravel.

140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.).

Abbreviations:
NR = Not Recorded.
DT = Drill Time.
HP = Hydraulic Pressure.
DFR = Drill Fluid Return.

15 20 25 30 35

SAJ FORM 1836-A
JUN 02

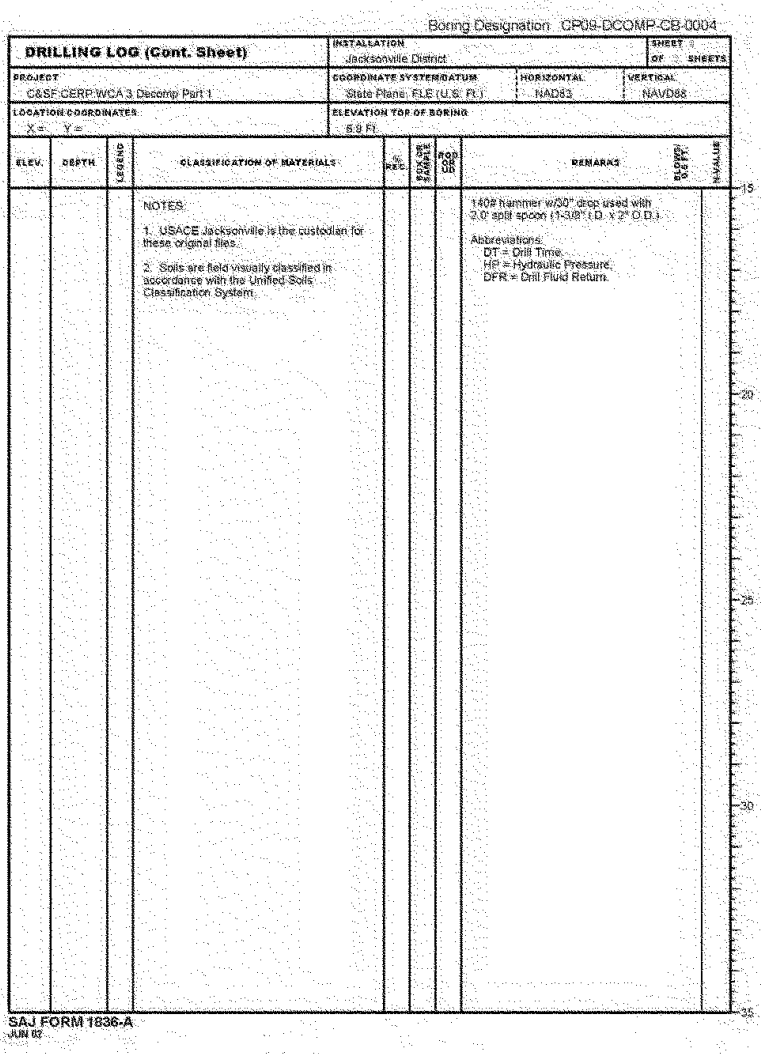
Boring Designation CP09-DCOMP-CB-0004

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET: 1 OF 2 SHEETS
1. PROJECT: C&SF CERP WCA 3 Decomp Part 1 L-67A Vicinity		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP09-DCOMP-CB-0004	LOCATION COORDINATES: X = Y =	11. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500	AUTO HAMMER / MANUAL HAMMER
3. DRILLING AGENCY: Corps of Engineers - CESAM	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED: 5 / UNDISTURBED (UD): 0
4. NAME OF DRILLER: C. Brown		13. TOTAL NUMBER CORE BOXES: 1	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER
		15. DATE BORING	STARTED: 06-30-09 / COMPLETED: 06-30-09
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 6.9 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: 49 %	
8. TOTAL DEPTH OF BORING: 15.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Jerrell Hand, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE #	ROD OR CORE	REMARKS	BLOWS/0.5 FT.	N-VALUE
6.9	0.0						6.9		
			SILT, organic-C, few peat, wet, 2.5YR 2.5/1 reddish black (OL)	33	1		SPT Sampler	3, 6, 2	8
							5.4		
				0			SPT Sampler	4, 3, 1	4
							3.9		
2.9	4.0			67	2		SPT Sampler	1, 0, 4	4
			LIMESTONE, hard, slightly weathered, very fine grained, 7.5YR 7/1 light gray		3		2.4		
				40	4		SPT Sampler	3, 6, 10	16
							0.9		
				53	5		SPT Sampler	5, 10, 50	60
0.6	7.5						-0.6		
			SILTSTONE, siliceous, hard, cavity, CAPROCK, slightly porous, carbonate trace calcite XLS, trace limonite, solution channels to 1.5", 2.5YR 8/1 white	80		ROD 32	6" Diamond Set Bit DT = 18 mins HP = 300 psi DFR = 0 %		
-2.3	9.2						-3.1		
			LIMESTONE, moderately hard, weathered, fine grained, porous, solution channels, 5YR 7/1 light gray		BOX 1				
			From El. -5.6 to -6.1 Ft., fine grained, cavity, partially filled vertical 1.5 in solution channel, 10YR 8/1 white	50		ROD 0	6" Diamond Set Bit DT = 25 mins HP = 300 psi DFR = 90 %		
-8.1	15.0						-8.1		

SAJ FORM 1836
JUN 02

(Continued)



Boring Designation: CP09-DCOMP-CB-0004

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 1 OF SHEETS
PROJECT: C&SF CERP WCA 3 Decomp Part 1	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = Y =	ELEVATION TOP OF BORING: 5.9 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	ROCK CORE SAMPLE	RQD CORE	REMARKS	BLOWS PER 0.5 FT.	N-VALUE
			NOTES: 1. USACE Jacksonville is the custodian for these original files. 2. Soils are field visually classified in accordance with the Unified Soils Classification System.				140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.). Abbreviations: DT = Drill Time. HP = Hydraulic Pressure. DFR = Drill Fluid Return.		

SAJ FORM 1836-A
JUN 02

REPORT OF GEOTECHNICAL EXPLORATION

L30SMPP Additional Drilling
TO#70
Miami, Florida
Contract W912EP-05-D-0009
WOLF/WPC Project No. WPC6208.00036

- Prepared For -

U.S. Army Corp of Engineers
Mr. Webster Shipley
701 San Marco Blvd, 3 East
Jacksonville, FL 32207

- Prepared By -

WOLF/WPC
3047-4 St. Johns Bluff Road South
Jacksonville, Florida 32246

WPC ENGINEERING, ENVIRONMENTAL & CONSTRUCTION SERVICES

LISTEN • RESPOND • PERFORM

December 11, 2008

Mr. Webster Shipley
U.S. Army Corps of Engineers
701 San Marco Boulevard, 3 East
Jacksonville, Florida 32207

Final Conceptual Geotechnical Data Report
L30SMPP Additional Drilling
Contract W912EP-05-D-0009
Miami-Dade County, Florida
WOLF/WPC Project No. WPC6208.00036

Dear Mr. Shipley:

WOLF/WPC has performed the additional field and laboratory geotechnical services for the L30 Seepage Management Pilot Project (SMPP). This conceptual report presents our understanding of the project, outlines our exploratory procedures, and presents the field and laboratory data obtained for the project.

We have enjoyed assisting you on this project and look forward to serving as your geotechnical consultant on the remainder of this project and on future projects. If you have any questions concerning this report, please contact us.

Respectfully Submitted,
WOLF/WPC

Jason R. Mckinnon, P.E.
Project Engineer
Registered, Florida No. 58696

Thomas J Casey, P.E.
Senior Geotechnical Engineer
Registered, Florida No. 62245

Distribution: U.S. Army Corps of Engineers (3)
File (1)

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APPENDICES

APPENDIX A
Site Location Map
Field Exploration Plan

APPENDIX B
Drilling Logs for SPT Borings
Photographs

APPENDIX C
Summary of Laboratory Testing Results

SECTION 1.0 – INVESTIGATION SCOPE

The scope of services for this investigation was provided in the statement of work (SOW) dated February 6, 2008, and was performed under the existing contract W912EP-05-D-0009. The requested field scope of services for this investigation included performing three (3) Standard Penetration Test (SPT) borings with rock coring. The laboratory testing scope of services included performing miscellaneous classification and index property tests, including unconfined compressive strength, visual shell content, and specific gravity determinations.

The project site is shown on the Site Location Map and Field Exploration Plan in Appendix A of this report. The depth of the SPT borings was 90 feet below the existing ground surface, or approximate elevation EL. -76.0. Laboratory classification and index property testing was assigned by Mr. Shipley following review of preliminary field drilling logs.

SECTION 2.0 – INVESTIGATION PURPOSE

The purpose of the exploratory drilling is to identify subsurface conditions in the right-of-way of the access road adjacent to the Canal L-30 Levee. The project is located west of Miami in Miami-Dade County near the intersection of Krome Avenue and Highway 41.

SECTION 3.0 – GEOLOGICAL SETTING

The Biscayne Aquifer is composed of Miami Limestone and the Fort Thompson Formation. The Miami Limestone is typically characterized as soft to moderately hard, moderately to highly weathered, thick bedded, highly burrowed in the project area, white to yellow, and contains abundant solution cavities. In the uppermost part of the Miami Limestone, the solution cavities are commonly filled with loose quartz sand and peat. The Fort Thompson Formation lies unconformably beneath the Miami Limestone and is comprised of thick units of soft to hard, moderately weathered, light gray, limestone and sandy limestone that contains marine fossils and calcareous sandstone with a few thin beds of fresh water limestone. In the Project area, the Fort Thompson Formation commonly has zones that contain many vugs and much less commonly can contain cavities up to several feet in diameter.

The Pinecrest Sand Member of the Tamiami Formation creates a semi-confining unit within the Surficial Aquifer System. It lies unconformably beneath the Fort Thompson

Formation and is commonly comprised of quartz sand, limestone, and sandstone that is moderately hard and creamy white to greenish gray with uncommon soft layers of silty, clayey, and shelly sands. A grey limestone, also known as the Ochopee Limestone Member of the Tamiami Formation, lies unconformably below the Pinecrest Sand Member.

SECTION 4.0 – FIELD EXPLORATION

4.1 General

The field exploration conducted for this investigation included performing three (3) SPT borings with rock coring at locations specified by the U.S. Army Corps of Engineers (USACE).

Exploration point coordinates (Latitude and Longitude) were provided by USACE. The exploration points were initially laid out using a Trimble GeoXH handheld GPS device. We also converted the Latitude and Longitudes to State Plane Coordinates using the conversion program CORPSCON. The following table summarizes the exploration locations and depths:

Table 4.1-Summary of Exploration Point Locations and Depths

POINT NAME	LOCATION COORDINATES				EXPLORATION DEPTH, FEET	DATE PERFORMED
	NORTHING (Y)	EASTING (X)	LATITUDE	LONGITUDE		
CP07-L30PP-CB-0007	523,542	825,597	25° 46 23.04	80° 29 09.68	90	5/22/08
CP07-L30PP-CB-0008	523,820	825,595	25° 46 25.79	80° 29 06.51	90	5/21/08
CP07-L30PP-CB-0009	524,095	825,886	25° 46 28.5	80° 29 03.32	89	5/15/08

4.2 SPT Borings

The borings utilized Standard Penetration Test (SPT) split spoon sampling (ASTM D 1586) conducted continuously with 1.5-foot sample intervals in the upper 20 feet. The borings were advanced using mud rotary drilling process using recirculated drilling slurry to stabilize the borehole walls and flush the cuttings. Once the borings reached about 20 feet, the holes were reamed and widened and casing was set in the boreholes to maintain stability within the dike soils. The borings were then advanced thru intact limestone layers using a 5-foot long core barrel. Rock coring continued to depths ranging from 73.5 feet to 75 feet below the existing ground surface, then the split-spoon sampler was re-attached and continuous SPT sampling resumed to the termination depth of the borings. Once the borings were completed, they were airlifted with a compressed air

hose to remove excess sand from the borehole.

At the completion of each boring, geophysical logging was performed by personnel from the United States Geological Survey (USGS) on each borehole. The SPT boring Drilling Logs are presented in Appendix B of this report.

SECTION 5.0 – LABORATORY TESTING

Following review of the preliminary field logs, Mr. Shipley assigned several laboratory tests on samples obtained from the drilling operation. The laboratory testing conducted for this exploration included the following:

- 3 Visual Percent Shell Content
- 3 Specific Gravity Determinations for Rock (ASTM D 854)
- 3 Unconfined Compressive Strength Tests for Rock (ASTM D 2938-95)

The results of the laboratory testing and index property testing are presented in Appendix C of this report.

SECTION 6.0 – SUBSURFACE PROFILE

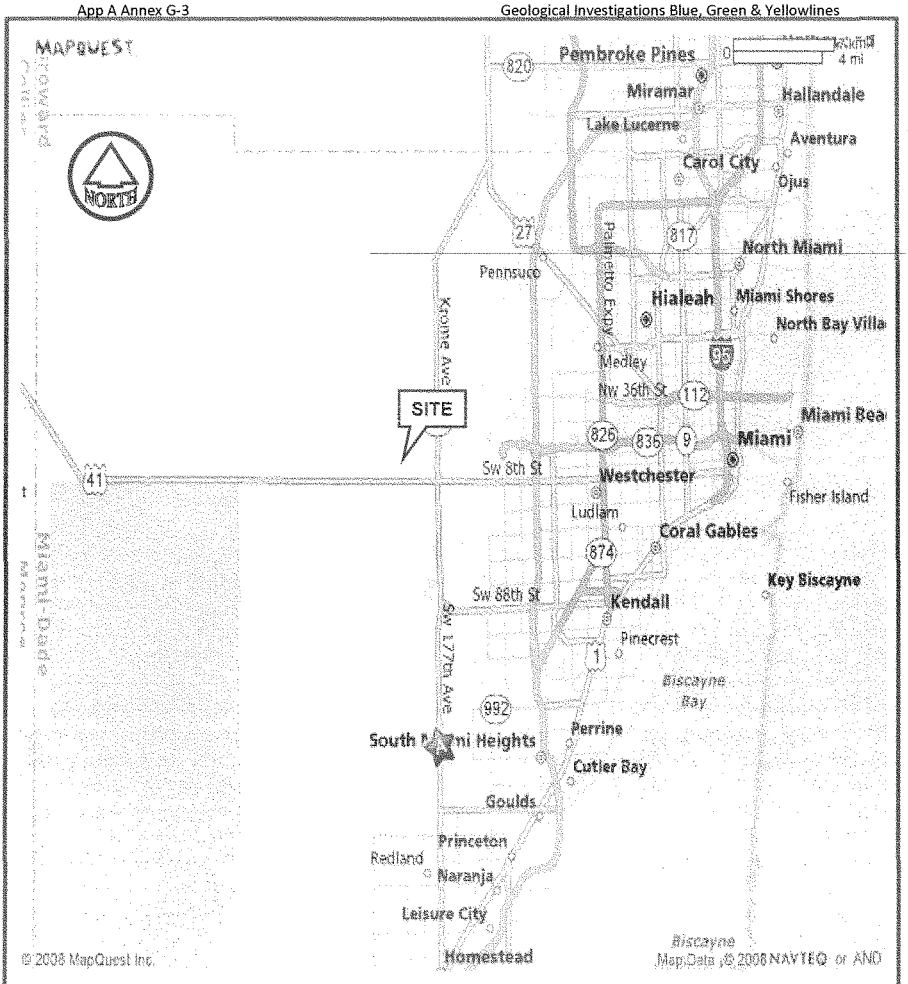
The encountered soils were classified using the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488. The subsurface conditions encountered at the site generally consisted of mixed levee fill materials consisting of sands (SP/SM), clay (CH), silt (ML), and/or limestone gravel (GP) to depths ranging from about 16 feet to 17 feet, at which point a thin layer (1 foot to 1.5 feet thick) of organic peat (PT) was encountered. The borings then generally encountered limestone to depths ranging from about 73.5 feet to 75 feet below ground surface. Below the intact limestone layers, the borings generally encountered sands (SP), silty sands (SM), silts (ML), clay (CH), sand-gravel mixtures (GP), and clay-limestone gravel mixtures (GC) to the termination depth of 89 feet to 90 feet below ground surface. SPT N-values generally ranged from very loose to very dense throughout the subsurface profiles.

The groundwater level was encountered by the SPT borings at depths of approximately 18 feet below the existing ground surface. It should be noted that groundwater levels will fluctuate due to seasonal rainfall fluctuations, distance to relief points or water features, soil drainage characteristics, and construction operations.

APPENDICES

APPENDIX A

- **Site Location Map**
- **Field Exploration Plan**



REFERENCE:
www.mapquest.com

WOLF WPC ENGINEERING, ENVIRONMENTAL & CONSTRUCTION SERVICES

SITE LOCATION MAP

L30 SMPP
Miami, Florida

WOLF/WPC Project No.: WPC6208.00036
Date: 8/12/2008

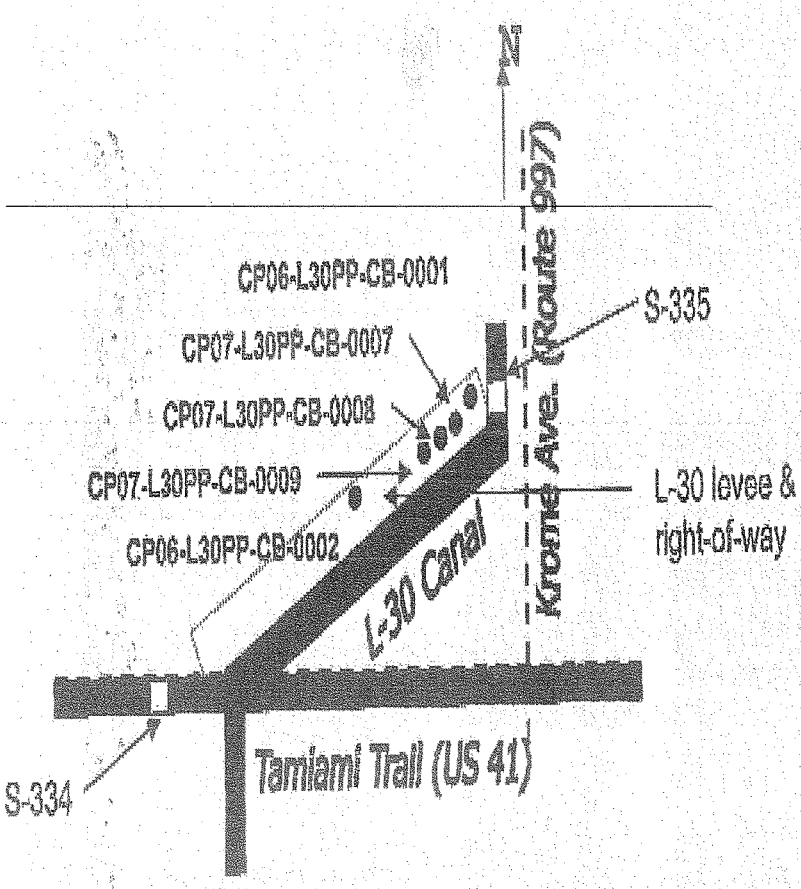


Figure 1: Boring and Well Locations

REFERENCE: ACOE SOW

WOLF WPC ENGINEERING, ENVIRONMENTAL & CONSTRUCTION SERVICES

FIELD EXPLORATION PLAN

L30 SMPP
Miami, Florida

WOLF/WPC Project No.: WPC6208.00036 Date: 8/12/2008

APPENDIX B

- Drilling Logs for SPT Borings
- Photographs

Boring Designation CP07-L30PP-CB-0007

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 5 SHEETS

1. PROJECT: L-30 Seepage Management Pilot Project		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP07-L30PP-CB-0007	LOCATION COORDINATES: X = 825,597 Y = 523,542	11. MANUFACTURER'S DESIGNATION OF DRILL	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Amdrill	CONTRACTOR FILE NO.	12. TOTAL SAMPLES: 24	DISTURBED: 24 / UNDISTURBED (UD): 0
4. NAME OF DRILLER: Adam Benson		13. TOTAL NUMBER CORE BOXES: 11	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: -4.0 Ft.
			15. DATE BORING: STARTED 05-13-08 / COMPLETED 05-14-08
6. THICKNESS OF OVERBURDEN: N/A			16. ELEVATION TOP OF BORING: 14.0 Ft.
7. DEPTH DRILLED INTO ROCK: N/A			17. TOTAL RECOVERY FOR BORING: 52 %
8. TOTAL DEPTH OF BORING: 90.0 Ft.			18. SIGNATURE AND TITLE OF INSPECTOR: Mark Holmes,

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX OR SAMPLE	ROD OR UD	REMARKS	BLOWS/0.5 FT.	N-VALUE
14.0	0.0						14.0		
			SAND, poorly-graded, dense to medium dense, mostly fine-grained sand-sized quartz, some sand to gravel-sized limestone, Levee Fill Material, 10YR 7/2 light gray (SP)	50	1		SPT Sampler	21 30 15	45
							12.0	12	
				30	2		SPT Sampler	8 8 18	26
							10.0	9	
9.0	5.0			0	3		SPT Sampler 9.0	4 4	
			GRAVEL, poorly-graded, medium dense, mostly sand to cobble-sized limestone, few fine-grained sand-sized quartz, few clay, 10YR 8/2 very pale brown (GP)	33	4		SPT Sampler	4 8 12	20
							7.5		
				33	5		SPT Sampler	5 7 5	12
							6.0		
				33	6		SPT Sampler	5 5 6	11
							4.5		
			At El. 4.5 Ft., loose, mostly sand to cobble-sized limestone, some clay, few fine-grained sand-sized quartz, 10YR 8/2 very pale brown	33	7		SPT Sampler	3 5 5	10
							3.0		
2.5	11.5								
			GRAVEL, poorly-graded, medium dense, mostly sand to cobble-sized limestone, some clay, few fine-grained sand-sized quartz, 10YR 8/2 very pale brown (GP)	33	8		SPT Sampler	6 9 8	17
1.0	13.0						1.5		
			CLAY, fat, stiff to soft, mostly clay, few shell, 10YR 3/3 dark brown (CH)	33	9		SPT Sampler	7 6 3	9
							0.0		
				7	10		SPT Sampler	2 2	

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(Continued)

Boring Designation CP07-L30PP-CB-0007

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 2 OF 5 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 825,597 Y = 523,542	ELEVATION TOP OF BORING: 14.0 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD RUN	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
				7	10		-1.5 SPT Sampler	2	4
-2.5	16.5			13	11		SPT Sampler	2 3 2	5
-3.0	17.0		PEAT, soft, some clay, 10YR 3/3 dark brown (PT)				-3.0		
			LIMESTONE, 10YR 8/2 very pale brown	50	12		SPT Sampler	15 21 11	32
							-4.5		
				50	13		SPT Sampler	18 22 30	52
-6.0	20.0		LIMESTONE, fossiliferous, moderately hard, 10YR 8/2 very pale brown				-6.0		
				50	BOX 14	ROD 12			
							-11.0		
				85	BOX 15	ROD 47			
			At El. -14.0 Ft., sparsely fossiliferous, moderately hard, weathered, 10YR 8/2 very pale brown						
-16.0	30.0		LIMESTONE				-16.0		
		Weathered		75	BOX 16	ROD 26			
-19.5	33.5	Highly Weathered	At El. -19.0 Ft., very soft, highly weathered, 10YR 8/2 very pale brown LIMESTONE, soft, 10YR 8/2 very pale brown				-21.0		

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Boring Designation CP07-L30PP-CB-0007

DRILLING LOG (Cont. Sheet)	INSTALLATION Jacksonville District	SHEET 3 OF 5 SHEETS
PROJECT L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.)	HORIZONTAL NAD83 / VERTICAL NAVD88
LOCATION COORDINATES X = 825,597 Y = 523,542	ELEVATION TOP OF BORING 14.0 Ft	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR CORE SIZE	ROD FOR CORE	REMARKS	BLOWS PER 6 IN.	N-VALUE
		Highly Weathered	At El. -21.0 Ft., fossiliferous, soft, 10YR 8/2 very pale brown	90	BOX 17	RQD 71	-26.0		35
			At El. -26.0 Ft., fossiliferous, moderately hard, Unconfined Compression Test on sample from 42 - 45 feet, 10YR 7/1 light gray	65	BOX 18	RQD 40	-31.0		40
				85	BOX 19	RQD 70	-36.0		45
			At El. -36.0 Ft., sparsely fossiliferous, moderately hard, 5YR 8/2 pinkish white	40	BOX 20	RQD 30	-41.0		50
-41.0	55.0								55

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JUN 02

Boring Designation CP07-L30PP-CB-0007

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 4 OF 5 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 825,597 Y = 523,542	ELEVATION TOP OF BORING: 14.0 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR USD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			LIMESTONE, fossiliferous, very hard, 5YR 8/2 pinkish white	30	BOX 21	RQD 17	-46.0		55
			At El. -46.0 Ft., very hard, 10Y 7/1 light greenish gray	85	BOX 22	RQD 42	-51.0		60
		Highly Weathered	At El. -51.0 Ft., fossiliferous, 10Y 7/1 light greenish gray	85	BOX 23	RQD 79	-56.0		65
			At El. -55.0 Ft., 10YR 7/1 light gray	25	BOX 24	RQD 8	-59.5		70
-61.0	75.0			33	25		SPT Sampler -61.0	6 9 5	10 75

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JUN 02

Boring Designation CP07-L30PP-CB-0007

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 5 OF 5 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 825,597 Y = 523,542	ELEVATION TOP OF BORING: 14.0 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NUMBER	ROD USE	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			SAND, poorly-graded, medium dense, mostly subangular medium to coarse-grained sand-sized quartz, little shell, 5Y 6/3 pale olive (SP)	93	26		SPT Sampler -62.5	11 10 10	20
				60	27		SPT Sampler -64.0	3 4 11	15
-64.5	78.5								
-65.0	79.0		GRAVEL, poorly-graded, medium dense, little medium-grained sand-sized quartz, 5Y 6/3 pale olive (GP)	133	28		SPT Sampler -65.5	4 8 7	15
-66.0	80.0		CLAY, fat, stiff, few fine to coarse gravel-sized limestone, few quartz, few shell, 5Y 6/3 pale olive (CH)						
			SILT, inorganic-L, stiff to firm, little clay, few fine-grained sand-sized quartz, few shell, 5Y 6/3 pale olive (ML)	20	29		SPT Sampler -67.0	5 7 20	27
				93	30		SPT Sampler -68.5	5 5 6	11
				33	31		SPT Sampler -70.0	4 5 5	10
				33	32		SPT Sampler -71.5	2 2 3	5
-71.5	85.5								
-73.0	87.0		SAND, silty, dense, mostly fine to coarse-grained sand-sized quartz, little silt, few shell, trace clay, 5Y 6/3 pale olive (SM)	67	33		SPT Sampler -73.0	19 21 26	47
			SAND, poorly-graded, dense, mostly coarse-grained sand-sized quartz, few shell, 5Y 6/3 pale olive (SP)	33	34		SPT Sampler -74.5	21 20 23	43
				8	35		SPT Sampler -76.0	15 16 27	43
-76.0	90.0								
			NOTES: 1. Soils are field visually classified in accordance with the Unified Soils Classification System. 2. Additional Laboratory Testing Specific Gravity				140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.).		

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Boring Designation CP07-L30PP-CB-0008

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 5 SHEETS
1. PROJECT: L-30 Seepage Management Pilot Project		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP07-L30PP-CB-0008	LOCATION COORDINATES: X = 825,595 Y = 523,820	11. MANUFACTURER'S DESIGNATION OF DRILL	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Amdrill	CONTRACTOR FILE NO.	12. TOTAL SAMPLES: DISTURBED 22	UNDISTURBED (UD) 0
4. NAME OF DRILLER: Adam Benson		13. TOTAL NUMBER CORE BOXES: 12	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: -4.0 Ft.
		15. DATE BORING: STARTED 05-15-08	COMPLETED 05-16-08
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 14.0 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: 67 %	
8. TOTAL DEPTH OF BORING: 90.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Mark Holmes,	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	ROD OR UD	REMARKS	BLOWS/0.5 FT.	N-VALUE
14.0	0.0						14.0		
			SILT, inorganic-L, very stiff to stiff, Levee Fill material, 10YR 7/3 very pale brown (ML)	30	1		SPT Sampler	22 17 12	29
							12.5		
				30	2		SPT Sampler	9 10 7	17
							11.0		
				0	3		SPT Sampler	4 6 6	12
9.5	4.5						9.5		
			SAND, poorly-graded, medium dense, mostly subangular to subrounded fine to coarse-grained sand-sized quartz, 10YR 6/3 pale brown (SP)	65	4		SPT Sampler	5 5 8	13
8.0	6.0						8.0		
			GRAVEL, poorly-graded, loose to medium dense, few subangular to subrounded coarse-grained sand-sized quartz, 10YR 6/3 pale brown (GP)	50	5		SPT Sampler	4 4 4	8
							6.5		
				30	6		SPT Sampler	3 6 7	13
			At El. 5.0 Ft., loose to medium dense, little quartz, 10YR 6/3 pale brown				5.0		
				50	7		SPT Sampler	5 5 5	10
							3.5		
				50	8		SPT Sampler	4 5 7	12
2.0	12.0						2.0		
			LIMESTONE, hard, 10YR 8/2 very pale brown	10	9		SPT Sampler	1 1 2	3
							0.5		
			At El. 0.5 Ft., 10YR 8/2 very pale brown	30	10		SPT Sampler	5 6 4	10
							-1.0		

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(Continued)

Boring Designation CP07-L30PP-CB-0008

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 2 OF 5 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 825,595 Y = 523,820	ELEVATION TOP OF BORING: 14.0 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	ROD OR CSD	REMARKS	BLOWS/0.5 FT.	N-VALUE
				25	11		SPT Sampler	3 2 4	6
-2.5									
-3.0	17.0		PEAT, stiff (PT)	80	12		SPT Sampler	6 18 30	48
-3.5	17.5		LIMESTONE, 10YR 7/1 light gray						
-4.0				60	BOX 13				
-6.0			At El. -6.0 Ft., sparsely fossiliferous, 10YR 7/1 light gray	95	BOX 14	RQD 12			
-11.0	25.0		LIMESTONE, fossiliferous, hard, 10YR 7/1 light gray	50	BOX 15	RQD 53			
-16.0									
-17.0	31.0		LIMESTONE, very soft, highly weathered, 10YR 7/1 light gray	75	BOX 16	RQD 58			
-17.5	31.5		LIMESTONE, fossiliferous, hard, 10YR 7/1 light gray						
-20.0	34.0		LIMESTONE, very soft, highly weathered, 10YR 7/1 light gray						
-20.5	34.5		LIMESTONE, fossiliferous, hard, Unconfined						
-21.0									

Highly Weathered

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JUN 02

Boring Designation CP07-L30PP-CB-0008

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 3 OF 5 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 825,595 Y = 523,820	ELEVATION TOP OF BORING: 14.0 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SPOON SIZE	RQD OR SPT	REMARKS	BLOWS/0.5 FT. N-VALUE	
			Compression test on sample from 35 - 40 feet, 10YR 7/1 light gray						35
-22.5	36.5		LIMESTONE, soft, highly weathered	95	BOX 17	RQD 81			
-26.0	40.0		LIMESTONE, fossiliferous, hard, 2.5YR 8/2 pinkish white				-26.0		40
				80	BOX 18	RQD 43			
							-31.0		45
			At El. -32.5 Ft., large marine fossils grading to smaller with depth	85	BOX 19	RQD 57			
-34.0	48.0		LIMESTONE, noticable burrowing increasing with depth, 2.5YR 8/2 pinkish white				-36.0		50
-38.0	52.0		LIMESTONE, soft, decreasing fossils and burrows, 2.5YR 8/3 pink	60	BOX 20	RQD 26			
							-41.0		55

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Boring Designation CP07-L30PP-CB-0008

DRILLING LOG (Cont. Sheet)	INSTALLATION Jacksonville District	SHEET 4 OF 5 SHEETS
PROJECT L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.)	HORIZONTAL NAD83 / VERTICAL NAVD88
LOCATION COORDINATES X = 825,595 Y = 523,820	ELEVATION TOP OF BORING 14.0 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
-43.0	57.0		LIMESTONE, hard, numerous marine fossils	85	BOX 21	RQD 32			
			At El. -46.0 Ft., fossiliferous				-46.0		
			At El. -48.0 Ft., grading to mudstone, with sand increasing with depth	60	BOX 22	RQD 18			
							-51.0		
				60	BOX 23	RQD 28			
-56.0	70.0						-56.0		
			SAND, poorly-graded, 10Y 8/1 light greenish gray (SP)						
			At El. -59.0 Ft., few fine to coarse-grained sand-sized shell, 10Y 8/1 light greenish gray	40	BOX 24	RQD 30			
							-61.0		

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Boring Designation CP07-L30PP-CB-0008

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 3 OF 5 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 825,595 Y = 523,820	ELEVATION TOP OF BORING: 14.0 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR GS	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			At El. -61.0 Ft., loose to medium dense, 5G 8/2 pale green	50	25		SPT Sampler	9 5 5	10
-62.5									
-63.0	77.0								
-63.5	77.5		SAND, clayey, loose (SC)	85	26		SPT Sampler	7 8 11	19
			SAND, poorly-graded, medium dense, few shell (SP)						
-64.0									
				50	27		SPT Sampler	7 10 14	24
-65.5									
-66.0	80.0								
-66.5	80.5		GRAVEL, poorly-graded, medium dense (GP)	90	28		SPT Sampler	4 9 14	23
			SAND, poorly-graded, medium dense, 10Y 3/1 dark greenish gray (SP)						
-67.0									
				90	29		SPT Sampler	10 11 11	22
-68.5									
				90	30		SPT Sampler	3 6 10	16
-70.0									
-70.5	84.5								
			SAND, silty, medium dense, 10Y 3/1 dark greenish gray (SM)	95	31		SPT Sampler	5 10 12	22
-71.5									
			At El. -72.0 Ft., loose to medium dense, 10Y 3/1 dark greenish gray	95	32		SPT Sampler	2 3 7	10
-73.0									
				100	33		SPT Sampler	6 5 5	10
-74.5									
				100	34		SPT Sampler	4 6 8	14
-76.0	90.0								
			NOTES: 1. Soils are field visually classified in accordance with the Unified Soils Classification System. 2. Additional Laboratory Testing Specific Gravity				140# hammer w/30" drop used with 2.0' split spoon (1-3/8" I.D. x 2" O.D.).		

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Boring Designation CP07-L30PP-CB-0009

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 5 SHEETS
1. PROJECT: L-30 Seepage Management Pilot Project		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP07-L30PP-CB-0009	LOCATION COORDINATES: X = 825,886 Y = 524,095	11. MANUFACTURER'S DESIGNATION OF DRILL	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Amdrill	CONTRACTOR FILE NO.	12. TOTAL SAMPLES	DISTURBED: 22 / UNDISTURBED (UD): 0
4. NAME OF DRILLER: Adam Benson		13. TOTAL NUMBER CORE BOXES: 12	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: -4.0 Ft.
		15. DATE BORING	STARTED: 05-19-08 / COMPLETED: 05-20-08
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 14.0 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: 53 %	
8. TOTAL DEPTH OF BORING: 89.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Larry Mattila,	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/0.5 FT.	N-VALUE
14.0	0.0						14.0		
			GRAVEL, poorly-graded, dense, Levee Fill Material (GP)	40	1		SPT Sampler	18, 26, 17	43
			From El. 12.5 to -3.5 Ft., dense to loose, trace clayey sand				12.5		
				40	2		SPT Sampler	16, 27, 11	38
							11.0		
				30	3		SPT Sampler	6, 6, 7	13
							9.5		
				30	4		SPT Sampler	6, 8, 14	22
							8.0		
				20	5		SPT Sampler	3, 4, 5	9
							6.5		
				30	6		SPT Sampler	5, 5, 5	10
							5.0		
				40	7		SPT Sampler	5, 6, 6	12
							3.5		
				20	8		SPT Sampler	6, 8, 7	15
							2.0		
				30	9		SPT Sampler	6, 10, 9	19
							0.5		
				20	10		SPT Sampler	4, 4, 4	8
							-1.0		

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JUN 82

(Continued)

Boring Designation CP07-L30PP-CB-0009

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 2 OF 5 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 825,886 Y = 524,095	ELEVATION TOP OF BORING: 14.0 Ft.	

ELEV.	DEPTH	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR CORE	REMARKS	BLOWS/0.5 FT.	N-VALUE
							3	
-2.0	16.0	PEAT, stiff, some clay (PT)	20	11		SPT Sampler	3	10
						-2.5	7	
-3.5	17.5	LIMESTONE, weathered, vuggy, white	40	12		SPT Sampler	4	36
						-4.0	15	
							21	
			60	BOX 13	RQD 31	-6.0		
-6.0	20.0	LIMESTONE, hard, weathered, vuggy, some micrite, white						
			80	BOX 14	RQD 66	-11.0		
		From El. -11.0 to -16.0 Ft., weathered, vuggy,, white						
			30	BOX 15	RQD 10	-16.0		
		From El. -16.0 to -21.0 Ft., weathered, vuggy, vugs filled with calcite sands, white						
			50	BOX 16	RQD 30	-21.0		

Weathered

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JUN 02

Boring Designation CP07-L30PP-CB-0009

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 3 OF 5 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 825,886 Y = 524,095	ELEVATION TOP OF BORING: 14.0 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR CSI	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			From El. -21.0 to -26.0 Ft., hard, weathered, trace vugs, shell molds, white	85	BOX 17	RQD 68			
							-26.0		
			From El. -26.0 to -31.0 Ft., weathered, vuggy, sparite in vugs, shell molds and some shells, Unconfined Compression test on sample from 38 - 40 feet, 10YR 7/1 light gray	90	BOX 18	RQD 73			
-31.0	45.0						-31.0		
			LIMESTONE, moderately hard, weathered, some vugs and shell molds, hard, white	90	BOX 19	RQD 81			
							-36.0		
			From El. -36.0 to -41.0 Ft., weathered, vuggy, sparite in vugs, white	65	BOX 20	RQD 20			
							-41.0		

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Boring Designation CP07-L30PP-CB-0009

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 4 OF 5 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 825,886 Y = 524,095	ELEVATION TOP OF BORING: 14.0 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	RQD OR CORE NO.	REMARKS	BLOWS/0.5 FT.	N-VALUE
			From El. -41.0 to -46.0 Ft., very vuggy, shell molds and marine fossils, white	20	BOX 21	RQD 0			
							-46.0		
			From El. -46.0 to -51.0 Ft., vuggy, some shell and sparite, white	55	BOX 22	RQD 8			
							-51.0		
			From El. -51.0 to -56.0 Ft., very vuggy, some shells and sparite, pinkish-tan	50	BOX 23	RQD 8			
							-56.0		
			From El. -56.0 to -60.0 Ft., somewhat vuggy, shell molds and sparite, light tan	80	BOX 24	RQD 78			
-60.0	74.0						-60.0		
			GRAVEL, poorly-graded, dense, mostly fine-grained sand-sized quartz, some fine to coarse gravel-sized limestone, light gray	60	24		SPT Sampler	14 / 16	

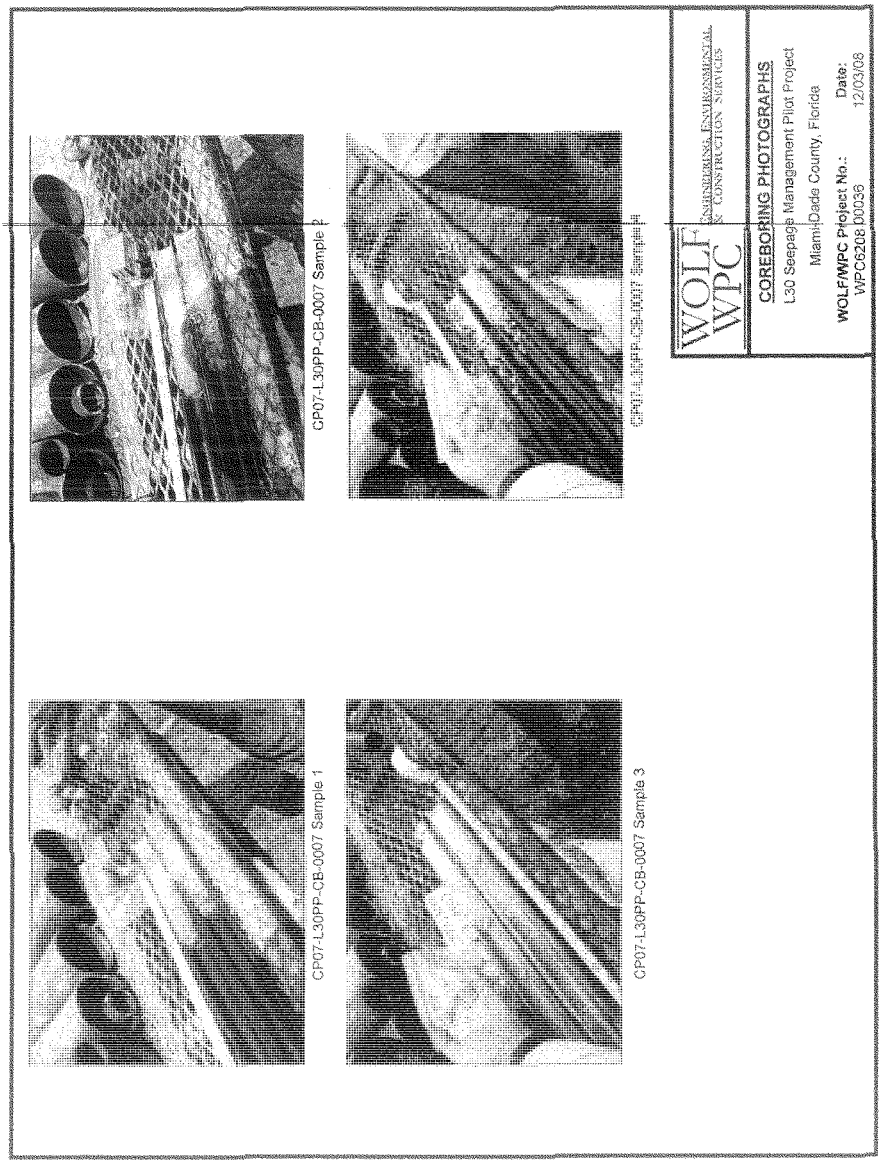
SAJ FORM 1836-A
JUN 02

Boring Designation CP07-L30PP-CB-0009

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 6 OF 5 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 825,886 Y = 524,095	ELEVATION TOP OF BORING: 14.0 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR BAG NO.	ROD OR CORE NO.	REMARKS	BLOWS/0.5 FT.	N-VALUE
			(GP)	60	24		-61.5 SPT Sampler	24	40
			From El. -61.5 to -63.0 Ft.; dense, some fine to coarse gravel-sized limestone, light gray	60	26		SPT Sampler -63.0	8 15 24	39
			From El. -63.0 to -64.5 Ft., dense, some subangular to subrounded fine to coarse gravel-sized limestone, light gray	50	27		SPT Sampler -64.5	10 19 12	31
			From El. -64.5 to -66.0 Ft., medium dense, light gray	90	28		SPT Sampler -66.0	11 14 11	25
-66.0	80.0		GRAVEL, clayey, medium dense to dense, some subrounded fine-grained sand-sized quartz, gray (GC)	90	29		SPT Sampler -67.5	5 7 11	18
				50	30		SPT Sampler -69.0	6 8 10	18
				80	31		SPT Sampler -70.5	7 14 18	32
				80	32		SPT Sampler -72.0	6 12 13	25
			From El. -72.0 to -75.0 Ft., dense to medium dense, some subrounded fine-grained sand-sized quartz, some shell, gray	60	33		SPT Sampler -73.5	8 15 18	33
					34		SPT Sampler -75.0	5 7 9	16
-75.0	89.0								
			NOTES: 1. Soils are field visually classified in accordance with the Unified Soils Classification System. 2. Additional Laboratory Testing Specific Gravity				140# hammer w/30" drop used with 2.0' split spoon (1-3/8" I.D. x 2" O.D.). Abbreviations: NR = Not Recorded.		

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JUN 02


CP07-L30PP-CB-0007 Sample 2
CP07-L30PP-CB-0007 Sample 4
CP07-L30PP-CB-0007 Sample 1
CP07-L30PP-CB-0007 Sample 3
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COREBORING PHOTOGRAPHS
L30 Seepage Management Pilot Project
Miami-Dade County, Florida
WOLF/WPC Project No.: WPC6208.00036
Date: 12/03/08



CP07-L30PP-CB-0007 Sample 6



CP07-L30PP-CB-0007 Sample 8



CP07-L30PP-CB-0007 Sample 5

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CP07-L30PP-CB-0007 Sample 7

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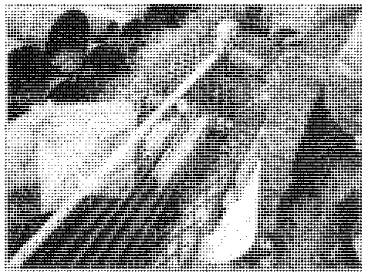
L30 Seepage Management Pilot Project

Miami-Dade County, Florida

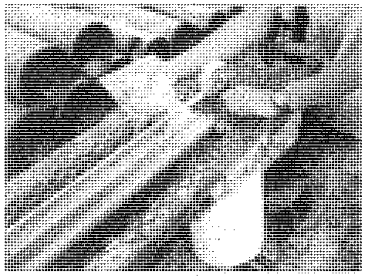
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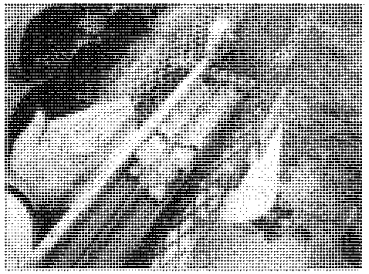
CP07-L30PP-CB-0007 Sample 9



CP07-L30PP-CB-0007 Sample 10



CP07-L30PP-CB-0007 Sample 11



CP07-L30PP-CB-0007 Sample 12

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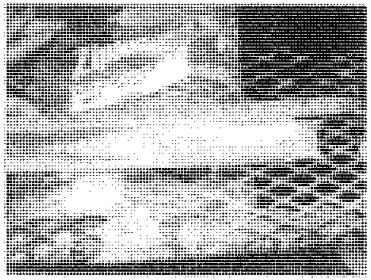
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L30 Seepage Management Pilot Project

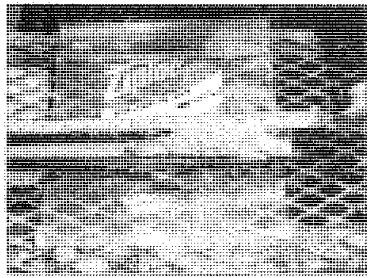
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L30 Seepage Management Pilot Project
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Date: 12/03/08
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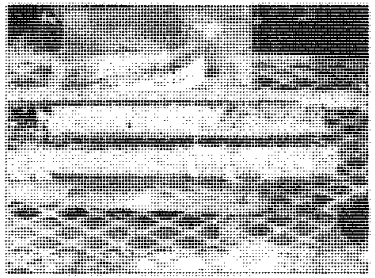
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CP07-L30PP-CB-0008 Sample 2

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CP07-L30PP-CB-0008 Sample 3



CP07-L30PP-CB-0008 Sample 4

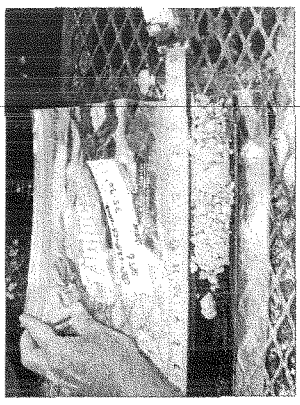
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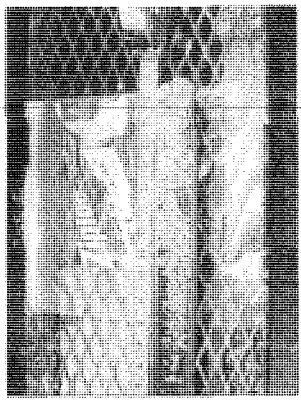
L30 Seepage Management Pilot Project

Miami-Dade County, Florida

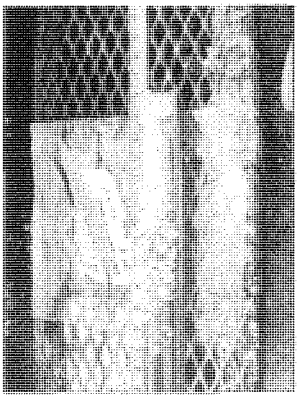
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WPC6208.00036	12/03/08



CP07-L30PP-CB-0008 Sample 6



CP07-L30PP-CB-0008 Sample 4



CP07-L30PP-CB-0008 Sample 5



CP07-L30PP-CB-0008 Sample 7

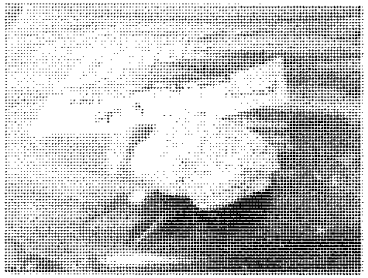
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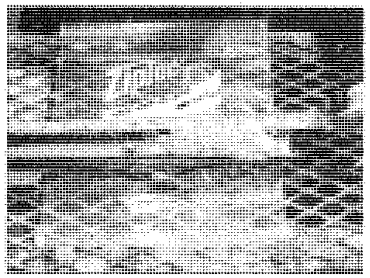
L30 Seepage Management Pilot Project

Miami-Dade County, Florida

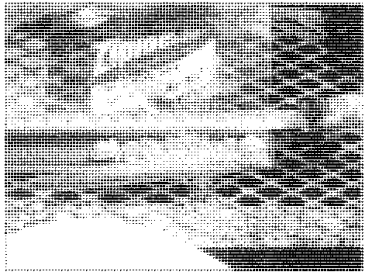
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CP07-L30PP-CB-0008 Sample 9



CP07-L30PP-CB-0008 Sample 10



CP07-L30PP-CB-0008 Sample 11



CP07-L30PP-CB-0008 Sample 12

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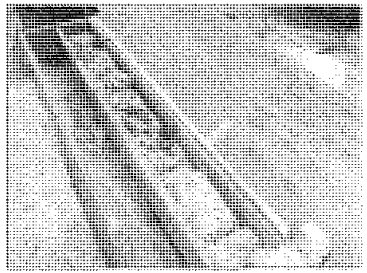
L30 Seepage Management Pilot Project

Miami-Dade County, Florida

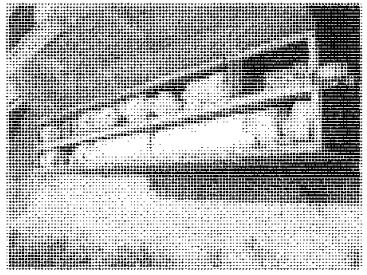
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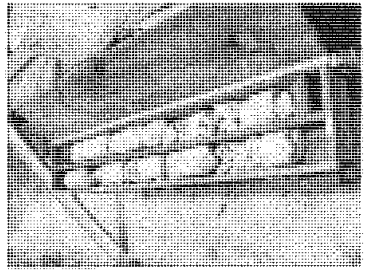
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CP07-L30PP-CB-0008 Sample 14 & 15



CP07-L30PP-CB-0008 Sample 16 & 17



CP07-L30PP-CB-0008 Sample 18 & 19

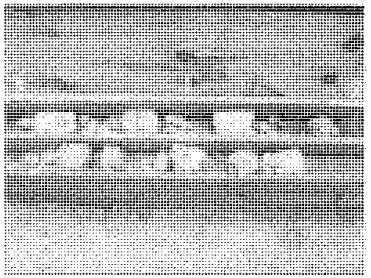
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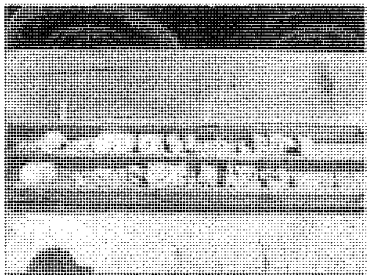
L30 Seepage Management Pilot Project

Miami-Dade County, Florida

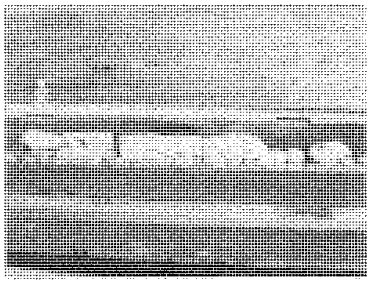
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WPC8208.00036	12/03/08



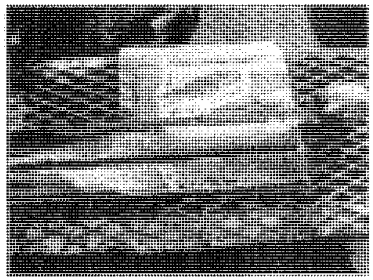
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CP07-L30PP-CB-0008 Sample 22 & 23



CP07-L30PP-CB-0008 Sample 24



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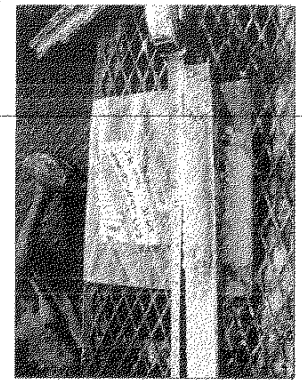
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COREBORING PHOTOGRAPHS

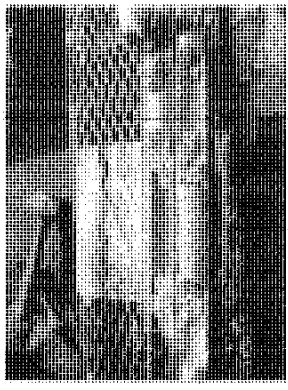
L30 Seepage Management Pilot Project

Miami-Dade County, Florida

WOLF/WPC Project No.:	Date:
WPC6208.00036	12/03/08



CP07-L30PP-CB-0008 Sample 27



CP07-L30PP-CB-0008 Sample 27

WOLF WPC

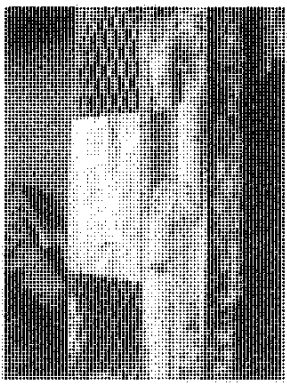
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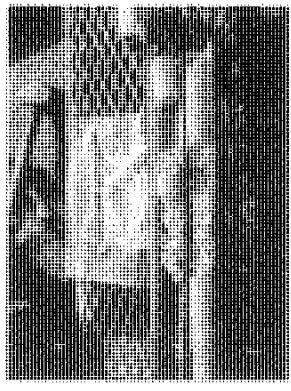
L30 Seepage Management Pilot Project

Miami-Dade County, Florida

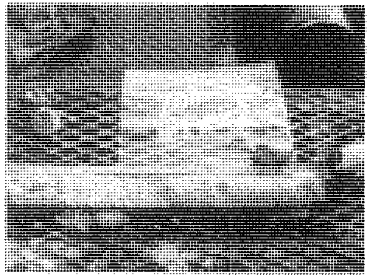
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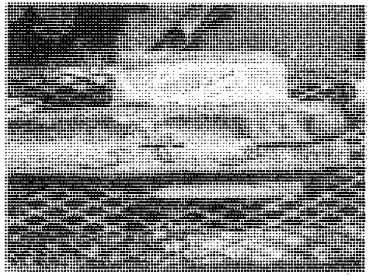
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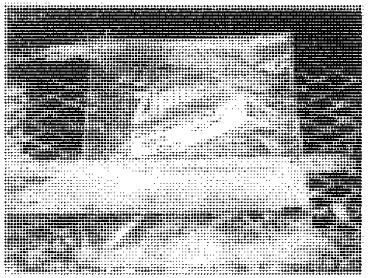
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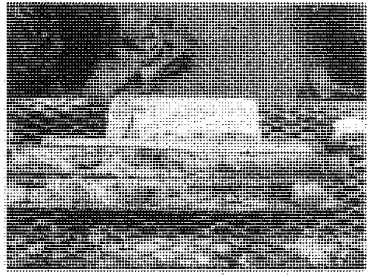
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CP07-L30PP-CB-0008 Sample 32



CP07-L30PP-CB-0008 Sample 33

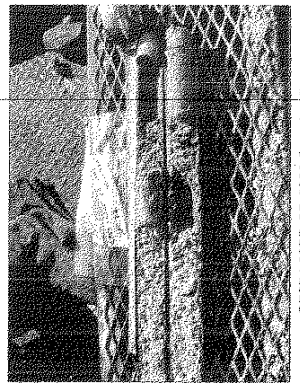
WOLF WPC Engineering, Environmental & Construction Services

COREBORING PHOTOGRAPHS

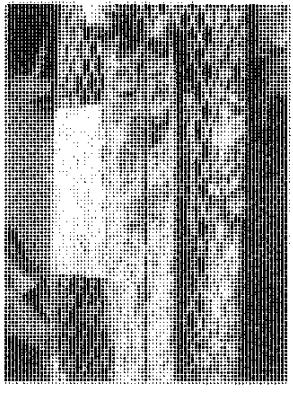
L30 Seepage Management Pilot Project

Miami-Dade County, Florida

WOLF/WPC Project No.:	Date:
WPC6208.00036	12/03/08



CP07-L30FP-CB-0008 Sample 35



CP07-L30FP-CB-0008 Sample 34

WOLF WPC

ENGINEERING ENVIRONMENTAL & CONSTRUCTION SERVICES

COREBORING PHOTOGRAPHS

L30 Seepage Management Pilot Project

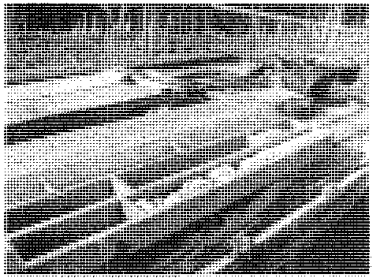
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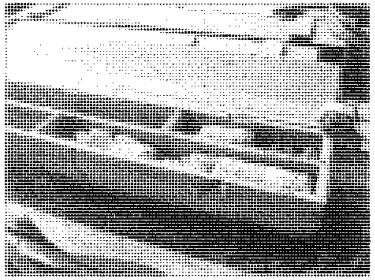
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FILES 1 THRU 12 CORRUPT

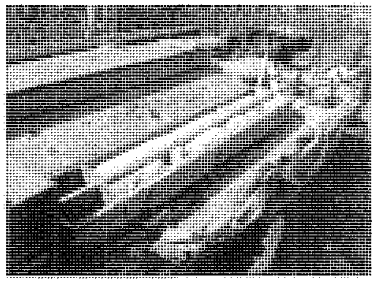
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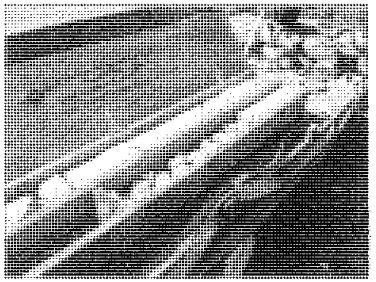
WOLF WPC Engineering, Environmental & Construction Services

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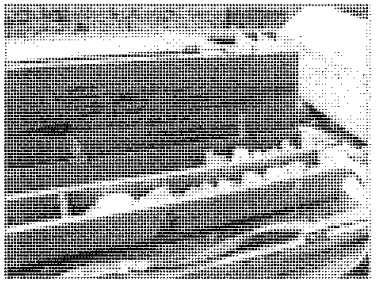
L30 Seepage Management Pilot Project

Miami-Dade County, Florida

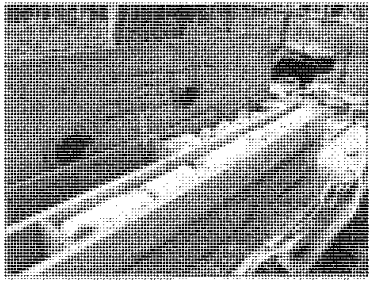
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WPC6208.00036	12/03/08



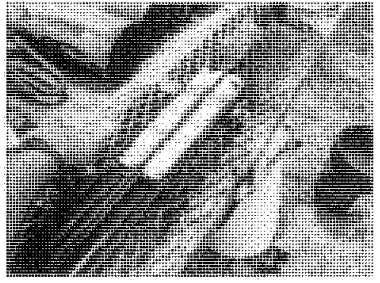
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CP07-L30PP-CB-0009 Sample 21 & 22



CP07-L30PP-CB-0009 Sample 23 & 24



CP07-L30PP-CB-0009 Sample 25

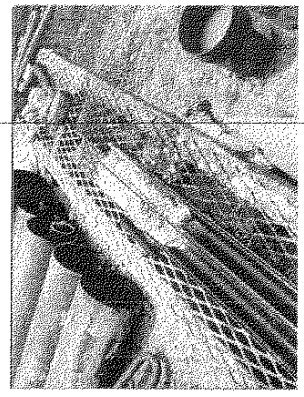
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COREBORING PHOTOGRAPHS

L30 Seepage Management Pilot Project

Miami-Dade County, Florida

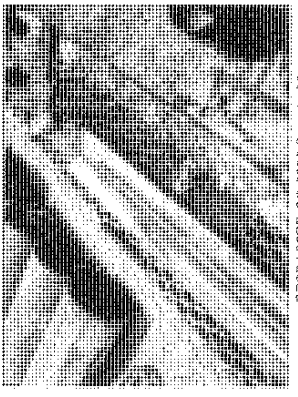
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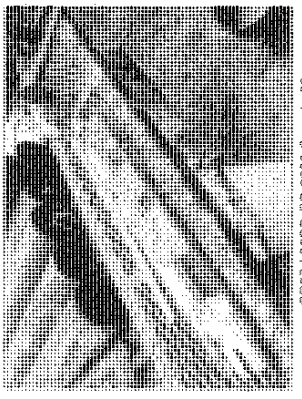
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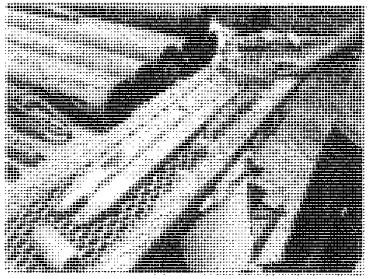
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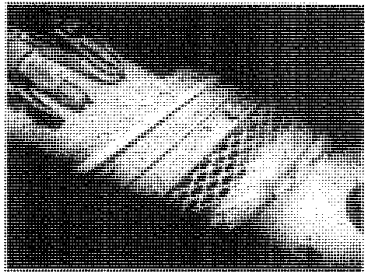
L30 Seepage Management Pilot Project

Miami-Dade County, Florida

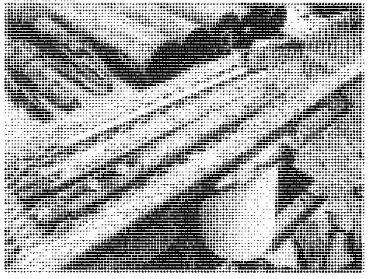
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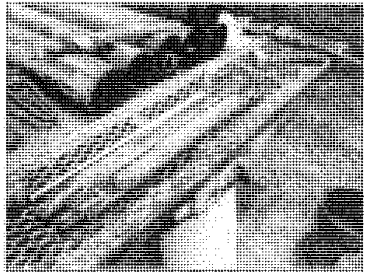
CP07-L30PP-CB-0009 Sample 30



CP07-L30PP-CB-0009 Sample 31



CP07-L30PP-CB-0009 Sample 32



CP07-L30PP-CB-0009 Sample 33

WOLF WPC ENGINEERING, ENVIRONMENTAL & CONSTRUCTION SERVICES

COREBORING PHOTOGRAPHS

L30 Seepage Management Pilot Project

Miami-Dade County, Florida

WOLF/WPC Project No.:	Date:
WPC6208.00036	12/03/08

CP07-L30PP-CB-0009 Sample 34

WOLF WPC ENGINEERING ENVIRONMENTAL & CONSTRUCTION SERVICES

COREBORING PHOTOGRAPHS

L30 Seepage Management Pilot Project

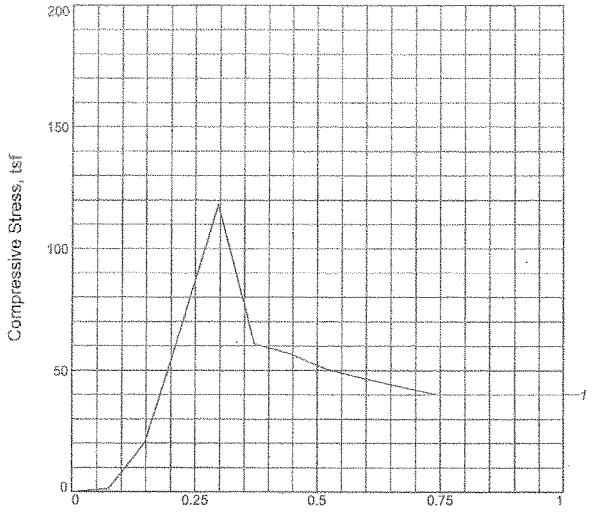
Miami-Dade County, Florida

WOLF/WPC Project No.: WPC8208.00036 **Date:** 12/03/08

APPENDIX C

- **Summary of Laboratory Test Results**

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	118.198			
Undrained shear strength, tsf	59.099			
Failure strain, %	0.3			
Strain rate, in./min.	0.06			
Water content, %	5.2			
Wet density, pcf	142.8			
Dry density, pcf	135.8			
Saturation, %	62.8			
Void ratio	0.2179			
Specimen diameter, in.	3.91			
Specimen height, in.	6.75			
Height/diameter ratio	1.73			

Description: Limerock Core, 10YR 7/1

LL =	PL =	PI =	GS= 2.65	Type: CORE

Project No.: WPC6308.00036

Date Sampled:

Remarks:

Client: USACE

Project: L-30 Seepage Management Pilot program

Location: CP07-L30PP-CB-007

Depth: 42.0'- 45.0'

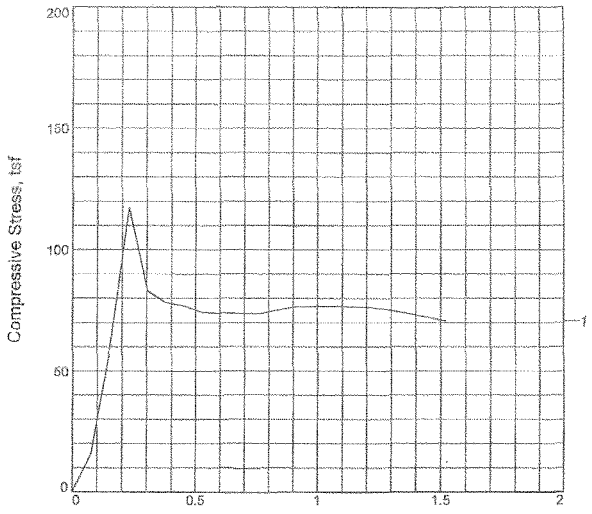
UNCONFINED COMPRESSION TEST

WPC

Figure _____

Tested By: C. Martin

UNCONFINED COMPRESSION TEST



Sample No.	1				
Unconfined strength, tsf	117.248				
Undrained shear strength, tsf	58.624				
Failure strain, %	0.2				
Strain rate, in./min.	0.03				
Water content, %	2.7				
Wet density, pcf	153.4				
Dry density, pcf	149.3				
Saturation, %	66.7				
Void ratio	0.1079				
Specimen diameter, in.	3.94				
Specimen height, in.	6.58				
Height/diameter ratio	1.67				

Description: Limerock Core, 10YR 7/1

LL =	PL =	PI =	GS= 2.65	Type: CORE

Project No.: WPC6308.00036

Date Sampled:

Remarks:

Client: USACE

Project: L-30 Seepage Management Pilot program

Location: CP07-L30PP-CB-008

Depth: 35.0'- 40.0'

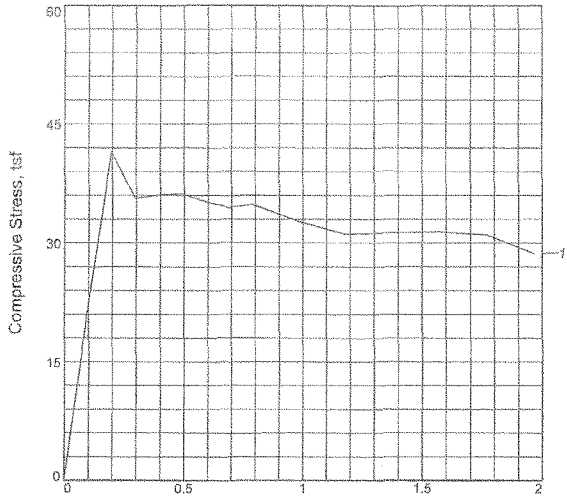
UNCONFINED COMPRESSION TEST

WPC

Figure

Tested By: C. Martin

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	41.458			
Undrained shear strength, tsf	20.729			
Failure strain, %	0.2			
Strain rate, in./min.	0.04			
Water content, %	7.2			
Wet density, pcf	148.0			
Dry density, pcf	138.1			
Saturation, %	96.3			
Void ratio	0.1983			
Specimen diameter, in.	3.95			
Specimen height, in.	5.08			
Height/diameter ratio	1.29			

Description: Limerock Core, 10YR 7/1

LL =	PL =	PI =	GS= 2.65	Type: CORE

Project No.: WPC0308.00036

Date Sampled:

Remarks:

Client: USACE

Project: L-30 Seepage Management Pilot program

Location: CP07-L30PP-CB-009

Depth: 38..0'- 40.0'

UNCONFINED COMPRESSION TEST

WPC

Figure _____

Tested By: C. Martin

SPECIALIZING IN SOILS EXPLORATION, PHYSICAL TESTING, ENGINEERING AND NDT EXAMINATION SERVICES

CHALLENGE ENGINEERING & TESTING, INC.

P. O. BOX 91537
4234 HALLS MILL ROAD
MOBILE, ALABAMA 36691
PHONE: (251) 666-1439
FAX: (251) 666-1438
EMAIL: CHALLENGETESTING@AOL.COM

FINAL REPORT
L-30 SEEPAGE MANAGEMENT PILOT PROJECT
WATER CONSERVATION AREA 3B
MIAMI-DADE COUNTY, FLORIDA

Contract # W912EP-05-D-0010
Delivery Order # 0003
Challenge Engineering & Testing, Inc.

Prepared For:
U.S. Army Corps of Engineers – Jacksonville District
Geotechnical Branch
701 San Marco Boulevard
Jacksonville, Florida 32207

Submitted By:
Challenge Engineering & Testing, Inc.
4234 Halls Mill Road
Mobile, Alabama 36691

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WATER CONSERVATION AREA 3B
MIAMI-DADE COUNTY, FLORIDA

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(1)

PURPOSE OF PROJECT

The U.S. Army Corps of Engineers is interested in determining the type, nature, and characteristics of lithological units that include the Biscayne Aquifer and the extent and conditions of the various materials as they exist to the depths at each of the locations specified.

The purpose of the L-30 Seepage Management Pilot Project (SMPP) is to address seepage management issues along the L-30 Canal related to the onset of other Comprehensive Everglades Restoration Plan (CERP) projects within the next five years.

The Pilot project is being conducted to provide information to determine the appropriate amount of wet season groundwater flow to return to the Everglades National Park (ENP) while minimizing potential impacts to the Miami-Dade West Well field and freshwater flows to Biscayne Bay.

This project is located west of Miami, Florida, northwest of the Tamiami Trail (US41) and Krome Avenue (Route 997). Work was performed along the top to the L-30 Canal Levee which runs mainly north-south and makes a 45 degree southwesterly departure from Krome Avenue toward the Tamiami Trail, commonly known as the "L-30 Triangle."

Challenge Engineering & Testing, Inc. of Mobile, Alabama was requested to assist the Jacksonville District of The U.S. Army Corps of Engineers on this contract.

SCOPE OF WORK

The scope of work consisted of performing in the upland (landside along top of L-30 levee) and in the freshwater wetland environment of the Water Conservation Area 3B the following:

- Core Drilling
- Wireline Core & Splitspoon Sampling
- Installation of Groundwater Monitoring Wells

Authorization to proceed with the requested tasks was issued on September 18th, 2006, Contract #W912EP-05-D-0010 – Delivery Order #0003 by the U.S. Army Corps of Engineers – Jacksonville District.

Field work was requested to be completed by November 19, 2006 for this assignment order.

(2)

PROCEDURES AND PROJECT SPECIFICATIONS

This report presents the procedures as followed for the borehole location, soil sampling and the classification of each respective soil sample in conjunction with special notes as recorded regarding conditions encountered in the field.

U.S. Army Corps of Engineer Standard Boring Log Forms 1836 are completed for each core boring performed in the designated location as generated with the Geotechnical Integrator "gINT" Software Program and script/library files as furnished by the Jacksonville District.

Drilling techniques and equipment were in general accordance with the prescribed technical provisions as stated in the Department of the Army Engineering Manual EM-1110-2-1907, "Soil Sampling" Publication.

FIELD WORK PERFORMED

PHASE I: TOP OF L-30 LEVEE LANDSIDE CORE BORINGS / WELL INSTALLATION

The landside well drilling phase of work on this project consisted of performing numerous tasks along the top of the L-30 Levee in designated test locations.

Boreholes were located utilizing the x-y coordinates as furnished by the Jacksonville District of the U.S. Army Corps of Engineers and converted by Corpscon to latitude/longitude for GPS location.

Three (3) borings were designated to be located along the top of the levee in the center of the roadway.

In each of the locations the following tasks were performed:

- Large diameter (10") roller bit was used to drill through the levee to top of rock
- PVC (8") surface casing set to top of rock
- Wireline rock coring was commenced with a five foot 4" x 5 ½" core barrel to the base of the rock formation with fresh water
- Boreholes were reamed with a seven and one-half inch (7.5") bit
- Boreholes developed for a period of three (3) hours with compressed air
- U.S. Geological Survey was notified of field progress
- Boreholes were allowed to remain for a minimum of 72 hours
- Borehole logging was performed by U.S.G.S.
- After approximately 7 days, drillcrew returned to perform continuous splitspoon sampling for an additional 30 feet
- Boreholes were backfilled with gravel and crushed limestone

The rig used on this project was a CME-55 four (4) wheel drive truck mounted hydraulic drill unit equipped with a standard manual 140 lb. splitspoon drive hammer and a Moyno reciprocating cavity unit pump.

Groundwater monitoring wells were installed approximately 10 ft. from each of the large diameter boreholes along the backside (south-canal)) top of levee. The construction consisted of two (2) inch diameter schedule 40 Johnson threaded joint "Tri-Lock" PVC installed with two (2) feet of 0.060" slotted screen.

Pea gravel backfill was used to fill the annulus around the screen.

A seal of 3/8" bentonite pellets was placed above the pea gravel. The remaining borehole annulus was backfilled with crushed limestone and gravel to the surface.

Flush mount security covers were completed encased in a three (3) foot by three (3) foot concrete pad. Locking top caps were placed on the well pipe.

The base of the Fort Thompson Formation was noted for each of the borings and reported in the below table. Splitspoon sampling was conducted for thirty (30) feet in the Pinecrest Sands below the Ft. Thompson Formation.

The computed horizontal coordinates for each of the borings to Florida East – NAD 83 State Plane Coordinates and vertical elevations to NAVD 1988 are reported as follows:

BORING/WELL DRILLING TEST LOCATIONS

Boring/Well Number	NAD 1983 Florida East Northing	Easting	Elevation (Ft.)	Base of Ft. Thompson
CP06-L30PP-CB-0001	524279	826073	17.27	- 57.7
CP06-L30PP-CB-0002	522044	823753	17.49	- 62.5
CP06-L30PP-CB-0003	519743	821358	17.19	- 57.1
			Top of Casing	
CP06-L30PP-MW-0001	524270	826074	17.12	
CP06-L30PP-MW-0002	522036	823753	17.10	
CP06-L30PP-MW-0003	519734	821356	16.87	

PHASE II:
WATER CONSERVATION AREA 3B
FRESHWATER WETLAND WELLS

Two (2) locations in the WCA3B were designated for monitoring wells and platforms to be constructed

(4)

Each site was drilled to termination depth with an amphibious track mounted drill setup. The wells were constructed and developed in the same manner as described above for the upland L-30 levee.

Surface casing consisted of installing six (6) inch schedule 80 PVC casing around the well and strapped to a four legged 2" galvanized steel pipe platform with a 48" treated wooden work deck.

WELL DRILLING TEST LOCATIONS

Boring/Well Number	NAD 1983 Florida East Northing	Easting	Top Of Casing
CP06-L30PP-MW-0004	526589	821601	12.00
CP06-L30PP-MW-0005	528482	824033	13.55

WELL DEVELOPMENT

The large diameter seven and one-half (7.5) inch boreholes were developed by insertion of tremmie pipe to the base of the reamed boreholes and using compressed air as supplied by a portable 185 CFM compressor to lift and blow out water and debris from boreholes. Each was developed for a period of a minimum of three (3) hours as the well was noted to produce "clear water".

Air bubbles were noted to be present rising to the surface waters on both sides of the levee for a distance of up to 105 feet from the well for a period of time of at least 20 minutes following development.

Each of the two (2) inch permanent groundwater monitoring wells was developed by pumping and surging until "clear" water was produced.

As per project specifications, an inventory of core boxes as prepared in the gINT format was submitted to Mrs. Karen Pitchford. The samples were placed in labeled wooden core boxes and delivered to the Corps of Engineer Warehouse on Talleyrand Avenue in Jacksonville, Florida on November 8, 2006. The core boxes were verified received by Mr. Mark Whitson and Dr. June Mirecki of the U.S. Army Corps of Engineers.

REPORT SUBMITTALS

The field boring logs, visual classifications and test results were all entered into the Geotechnical Integrator (gINT) software format as designed by the Jacksonville District which is presented as part of this report.

(5)

Digital project photographs were taken throughout the duration of the field work to document progress. Some the photographs are found attached as part of this report to include completed well installations.

Monitoring well construction diagrams are completed for each well.

FIELD EXPLORATION SUMMARY CONCLUSION

Coordination of field activities was conducted with Mr. Keith Price, Miami Field Office of the South Florida Water Management District during the term of this project.

During the field work on this project, coordination and updates were provided to Mr. Kevin Cunningham of the U.S. Geological Survey and U.S. Army Corps of Engineers Project Geologist Dr. June Mirecki of the Jacksonville District.

A special work permit was secured by Challenge Engineering Testing, Inc, through the Florida Fish and Wildlife Conservation Commission to work in the area due to excessive high water and public usage restrictions.

Challenge Engineering & Testing, Inc. has made every attempt to conduct this field project according to the project specifications and at the direction & satisfaction of all parties involved.

REPORT INVESTIGATION LIMITATIONS

The core borings, installation of the groundwater monitoring wells, analyses and recommendations submitted in this preliminary report are based on the data obtained from the field explorations performed at the locations depicted on the site plan. These locations were chosen by the U.S. Army Corps of Engineers, Jacksonville District. The area explored is limited to the depth and diameter of the core borings. This report does not reflect any variations which may occur adjacent to or between the core borings. The nature and extent of the variations between the borings may not become evident until during future excavations or construction in the area.

This report is based on relatively shallow explorations and a scope of work determined solely by the Corps of Engineers. This report does not include an evaluation of the environmental (ecological or hazardous/toxic material related) condition of the site and subsurface.

(6)

This report has been prepared for the exclusive use of the U.S. Army Corps of Engineers in accordance with generally accepted soil and foundation engineering practices.

It has been our pleasure for Challenge Engineering & Testing, Inc. to provide the U.S. Army Corps of Engineers – Jacksonville District our geotechnical engineering testing services on this project along the L-30 Levee & in the Water Conservation Area 3B.

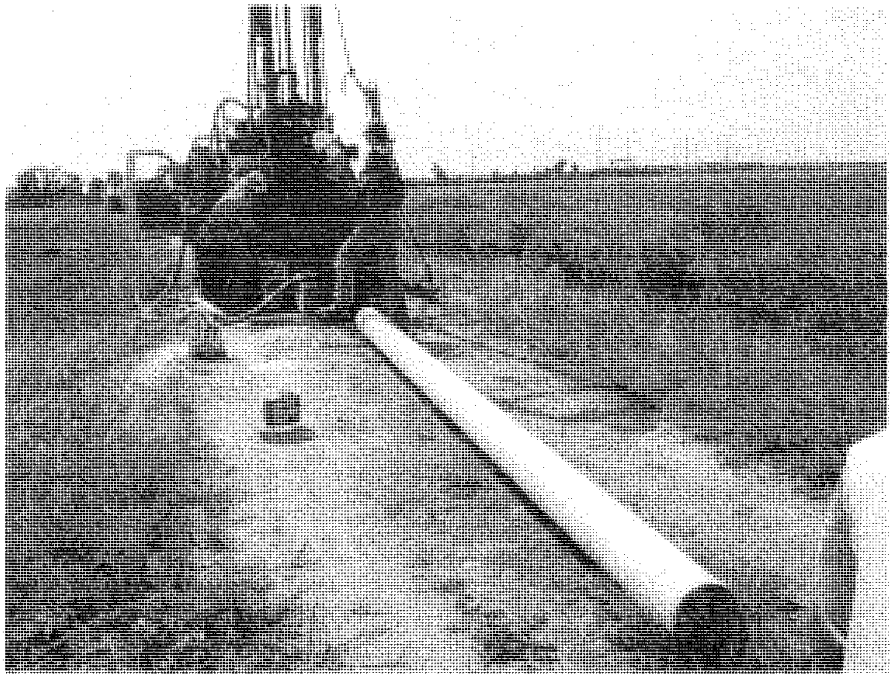
I trust that you will find this submittal to be in general conformance with the project guidelines and specifications.

Respectfully Submitted,
Challenge Engineering & Testing, Inc.

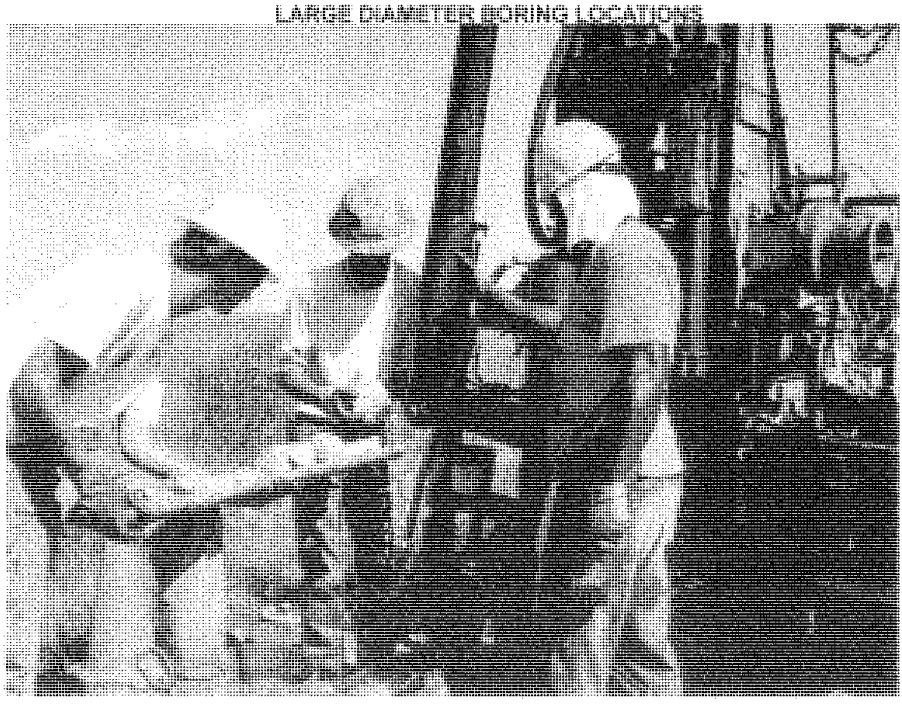
V. J. Thompson III, P.E.
Florida Registration # 37610

(7)

REFERENCE PROJECT PHOTOGRAPHS



8" SURFACE PVC CASING WAS SET AT EACH OF THE LARGE DIAMETER BORING LOCATIONS



4" WIRELINE CORING SYSTEM USED TO SAMPLE TO ROCK



7.5" OPEN BOREHOLES BEING AIR LIFTED WITH COMPRESSOR FOR 3 HOURS EACH PRIOR TO BEING LOGGED BY THE U.S.G.S.



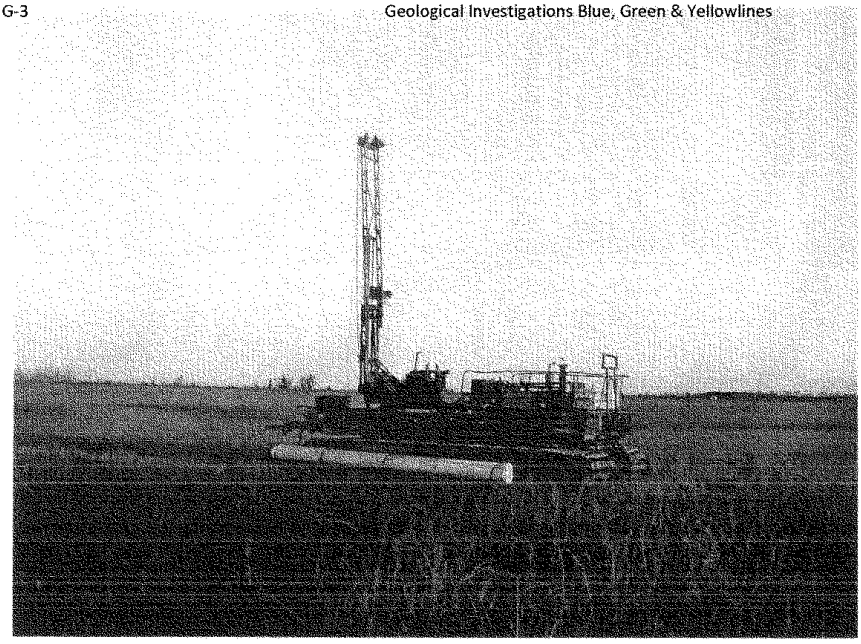
AIR BUBBLES WERE NOTED TO BE PRESENT ON BOTH SIDES OF THE LEVEE UP TO 105 FT. FROM BOREHOLES 10 MINUTES AFTER COMPRESSOR SHUTDOWN



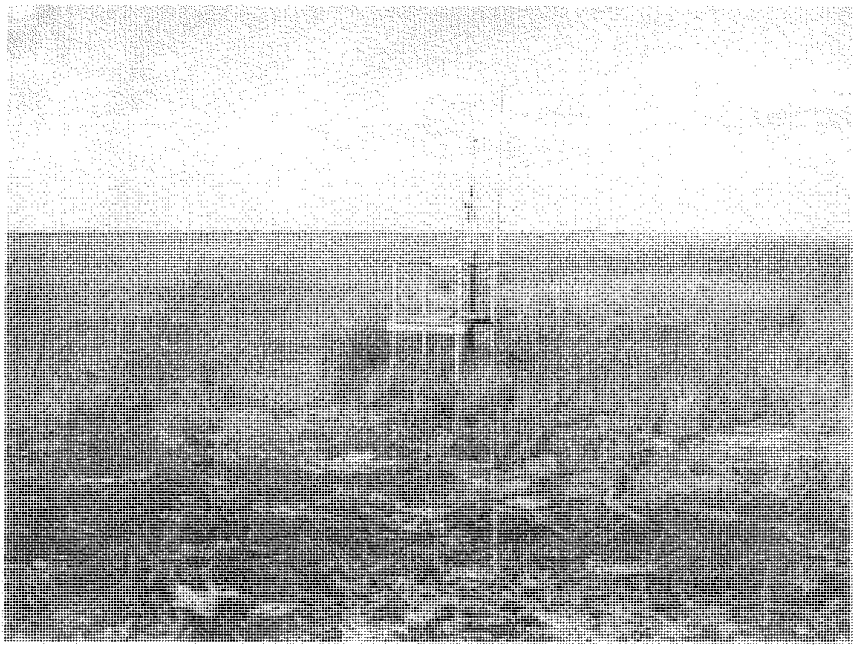
FLUSH MOUNT MONITORING WELL PADS CONSTRUCTED ON TOP OF L-30.
GPS POSITIONING CONDUCTED ON WELL CASING



COMPLETED FLUSH MOUNT WELL PAD ON SOUTHSIDE OF L-30
WITH BOLTDOWN MANHOLE COVER

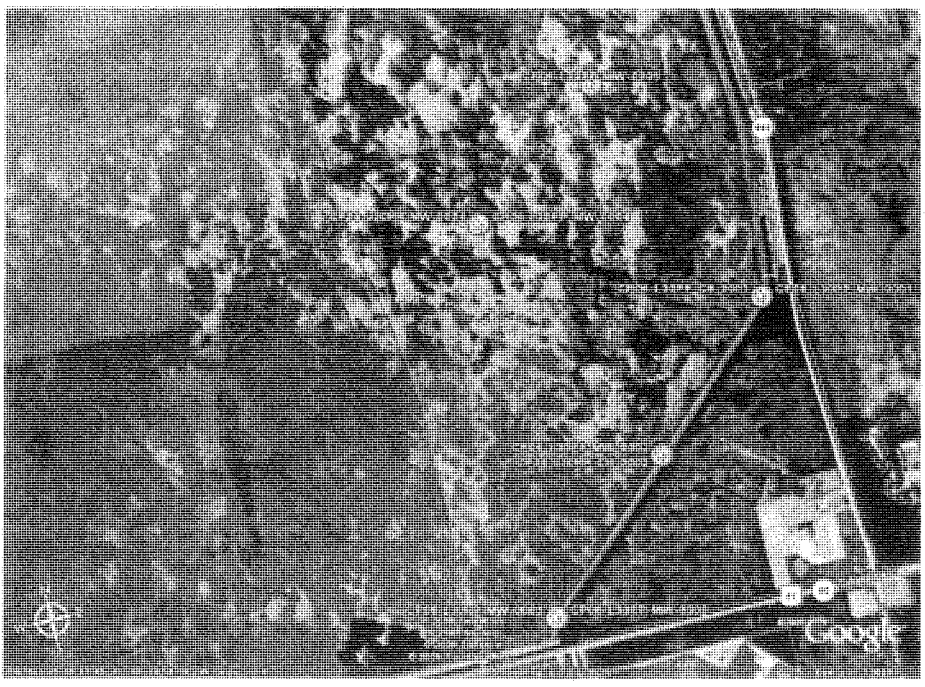


ATV SWAMP MOUNTED DRILL BUGGY ON-SITE



MONITORING WELL PLATFORM

BORING LOCATION MAP



LOCATION OF CORE BORINGS AND MONITORING WELLS
L-30 SEEPAGE MANAGEMENT PILOT PROJECT
DADE COUNTY, FLORIDA

SOILS TEST CORE BORING NUMBER "CP06-L30PP-CB-0001"

Miami-Dade County, Florida

Boring Designation CP06-L30PP-CB-0001

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 6 SHEETS

1. PROJECT: L-30 Seepage Management Pilot Project Top Of Levee L-30 (Center of Roadway)		9. SIZE AND TYPE OF BIT: See Remarks	
		10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
2. BORING DESIGNATION: CP06-L30PP-CB-0001	LOCATION COORDINATES: X = 826,073 Y = 524,279	11. MANUFACTURER'S DESIGNATION OF DRILL: CME 55 Truckrig	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Challenge Engineering & Testing, Inc.	CONTRACTOR FILE NO.: 2006D30	12. TOTAL SAMPLES: DISTURBED 33 / UNDISTURBED (UD) 0	
4. NAME OF DRILLER: Adam Benson		13. TOTAL NUMBER CORE BOXES: 5	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: 5.0 Ft.
			15. DATE BORING: STARTED 10-04-06 / COMPLETED 10-17-06
6. THICKNESS OF OVERBURDEN: N/A			16. ELEVATION TOP OF BORING: 17.3 Ft.
7. DEPTH DRILLED INTO ROCK: N/A			17. TOTAL RECOVERY FOR BORING: 79 %
8. TOTAL DEPTH OF BORING: 105.0 Ft.			18. SIGNATURE AND TITLE OF INSPECTOR: Bob Momberger, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD OR CB	REMARKS	BLOWS/ 0.5 FT. N-VALUE
17.3	0.0		L-30 Levee Fill Material				17.3	
							Advanced Boring w/ tricone roller bit	

0 5 10 15

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(Continued)

Boring Designation CP06-L30PP-CB-0001

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 2 OF 6 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 826,073 Y = 524,279	ELEVATION TOP OF BORING: 17.3 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	REC OR RQD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
							Advanced Boring w/ tricone roller bit		
-0.2	17.5						-0.2		
		Moderately Weathered	LIMESTONE, oolitic, fossiliferous, moderately hard, moderately weathered, aphanitic, pitted, Ft. Thompson Formation, 5Y 8/2 pale yellow	80	1	RQD 0	4 x 5-1/2" Diamond Impregnated Bit DT = 1 mins HP = 250 psi DFR = 25 %		
							-2.7		
		Weathered	From El. -2.7 to -11.2 Ft., weathered, thick bedding, vuggy	80	2	RQD 25	4 x 5-1/2" Diamond Impregnated Bit DT = 7 mins HP = 250 psi DFR = 25 %		
					BOX 1		-7.7		
			From El. -11.2 to -12.7 Ft., soft, 5Y 8/1 white	80	3	RQD 30	4 x 5-1/2" Diamond Impregnated Bit DT = 7 mins HP = 250 psi DFR = 0 %		
							-12.7		
		Slightly Weathered	From El. -12.7 to -17.7 Ft., moderately hard, slightly weathered, thick bedding, vuggy, 5Y 8/2 pale yellow	100	4	RQD 80	4 x 5-1/2" Diamond Impregnated Bit DT = 4 mins HP = 250 psi DFR = 0 %		
					BOX 2		-17.7		

SAJ FORM 1836-A
JUN 02

Boring Designation CP06-L30PP-CB-0001

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 3 OF 6 SHEETS	
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83	VERTICAL: NAVD88
LOCATION COORDINATES: X = 826,073 Y = 524,279	ELEVATION TOP OF BORING: 17.3 Ft.		

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR CORE	REMARKS	BLOWS/0.5 FT.	N-VALUE
		Unweathered	From El. -17.7 to -31.7 Ft., unweathered, aphanitic, massive bedding, vuggy, sand filled vugs, 5Y 8/1 white	90	5 BOX 2	RQD 70	4 x 5-1/2" Diamond Impregnated Bit DT = 3 mins HP = 250 psi DFR = 0 %		
			At El. -22.7 Ft., 2.5Y 8/1 white	100	6	RQD 100	-22.7 4 x 5-1/2" Diamond Impregnated Bit DT = 3 mins HP = 250 psi DFR = 0 %		
			From El. -31.7 to -32.7 Ft., fossiliferous, soft, porous, 5Y 8/1 white	65	7 BOX 3	RQD 43	-27.7 4 x 5-1/2" Diamond Impregnated Bit DT = 3 mins HP = 250 psi DFR = 0 %		
			From El. -32.7 to -37.7 Ft., moderately hard, thin bedding, vuggy	50	8	RQD 20	-32.7 4 x 5-1/2" Diamond Impregnated Bit DT = 5 mins HP = 250 psi DFR = 0 %		
							-37.7		

SAJ FORM 1836-A
JUN 02

Boring Designation CP06-L30PP-CB-0001

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 4 OF 6 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 826,073 Y = 524,279	ELEVATION TOP OF BORING: 17.3 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR RUN	REMARKS	BLOWS/0.5 FT. N-VALUE	
		Unconsolidated	From El. -37.7 to -47.7 Ft., medium bedding, vuggy, 2.5Y 8/1 white	50	BOX 3	RQD 20	4 x 5-1/2" Diamond Impregnated Bit DT = 4 mins HP = 250 psi DFR = 0 %		55
					9		-42.7		60
				100	BOX 4	RQD 55	4 x 5-1/2" Diamond Impregnated Bit DT = 4 mins HP = 250 psi DFR = 0 %		
			From El. -47.7 to -52.7 Ft., thick bedding, vuggy, clay filled vugs, 2.5Y 7/1 light gray				-47.7		65
				100	11	RQD 90	4 x 5-1/2" Diamond Impregnated Bit DT = 4 mins HP = 250 psi DFR = 0 %		
							-52.7		70
			From El. -52.7 to -57.7 Ft., thin bedding, sand filled vugs	25	BOX 5	RQD 25	4 x 5-1/2" Diamond Impregnated Bit DT = 4 mins HP = 250 psi DFR = 0 %		
-57.7	75.0				12		-57.7		75

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JUN 02

Boring Designation CP06-L30PP-CB-0001

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 5 OF 8 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 826,073 Y = 524,279	ELEVATION TOP OF BORING: 17.3 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE #	ROD OR USE	REMARKS	BLOWS/0.5 FT.	N-VALUE
-57.8	75.1		SAND, silty, mostly carbonate, Pinecrest Sand Formation (SM)	U	13	NQ1 0	4 X 5-1/2" Diamond Impregnated Bit	WOH	
			SHELL, mostly angular coarse gravel-sized flat and elongated shell up to 1", some coarse gravel-sized limestone up to 1-1/2", strong reaction with HCl, wet, 10Y 8/1 light greenish gray	27	14		SPT Sampler	0 0	0
-59.2									
				27	15		SPT Sampler	3 1 1	2
-60.7									
				50	16		SPT Sampler	1 1 1	2
-62.2	79.5								
			SAND, silty, mostly fine-grained sand-sized quartz, some angular sand to gravel-sized shell up to 1/2", few silt, strong reaction with HCl, wet, 10G 4/1 dark greenish gray (SM)	80	17		SPT Sampler	2 1 2	3
-63.7			At El. -63.7 Ft., low plasticity, trace clay						
				97	18		SPT Sampler	3 2 3	5
-65.2			At El. -65.2 Ft., nonplastic, mostly fine-grained sand-sized quartz, some angular sand to gravel-sized shell up to 1/2", few silt, strong reaction with HCl, wet, 5Y 6/1 gray	93	19		SPT Sampler	8 5 8	13
-66.7									
				97	20		SPT Sampler	2 3 14	17
-68.2									
				97	21		SPT Sampler	17 19 16	35
-69.7	87.0								
			SHELL, mostly angular fine to coarse gravel-sized flat and elongated shell up to 1/2", few silt, strong reaction with HCl, wet, 5Y 8/1 white	97	22		SPT Sampler	14 12 12	24
-71.2									
				90	23		SPT Sampler	12 10 10	20
-72.7									
				97	24		SPT Sampler	18 23 33	56
-74.2	91.5								
			SHELL, mostly fine-grained sand-sized quartz, some angular fine to coarse gravel-sized shell up to 1/2", few silt, strong reaction with HCl, wet, 5Y 8/1 white	97	25		SPT Sampler	16 18 29	47
-75.7			At El. -75.7 Ft., weak cementation						
				90	26		SPT Sampler	12 14 15	29
-77.2									
-77.7	95.0			97	27		SPT Sampler	22	

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JUN 82

Boring Designation CP06-L30PP-CB-0001

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 6 OF 6 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 826,073 Y = 524,279	ELEVATION TOP OF BORING: 17.3 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE #	ROD OR CORE	REMARKS	BLOWS/0.5 FT.	N-VALUE
			SHELL, mostly angular coarse gravel-sized flat and elongated shell up to 1-1/2", little fine-grained sand-sized quartz, strong reaction with HCl, wet, weak cementation, 5Y 8/1 gray	97	27		SPT Sampler	25 45	70
							-78.7		
				97	28		SPT Sampler	29 9 9	18
-80.2	97.5						-80.2		
			SAND, silty, mostly fine to coarse-grained sand-sized sandstone up to 1/2", little fine to medium-grained sand-sized shell up to 1/8", strong reaction with HCl, wet, weak cementation, 5Y 7/1 light gray (SM)	90	29		SPT Sampler	10 7 8	15
							-81.7		
				90	30		SPT Sampler	7 11 10	21
							-83.2		
			At El. -83.7 Ft., some fine to medium-grained sand-sized shell up to 1/2"	90	31		SPT Sampler	14 24 23	47
							-84.7		
				90	32		SPT Sampler	15 6 5	11
							-86.2		
				90	33		SPT Sampler	12 12 14	26
-87.7	105.0						-87.7		

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

2. Set 17.5 Ft. of 8" Schedule 40 PVC Pipe Through Center of L-30 Levee To Top of Rock.

3. Boring Drilled/Sampled In Three Phases;
A. Set Surface Casing.
B. 4" Wireline Rock Coring To Base Of Rock.
C. Splitspoon Sampling 30 Ft. Below Base of Rock.

4. Borehole Reamed To 7.5" To Base of Rock. USGS Performed Borehole Logging.

5. 2" Monitoring Well Set @
X = 826074 Y= 524270

Screen From -42.1 to -44.1 Ft.

6. Cored to 80 Ft. To Confirm Out of Rock.

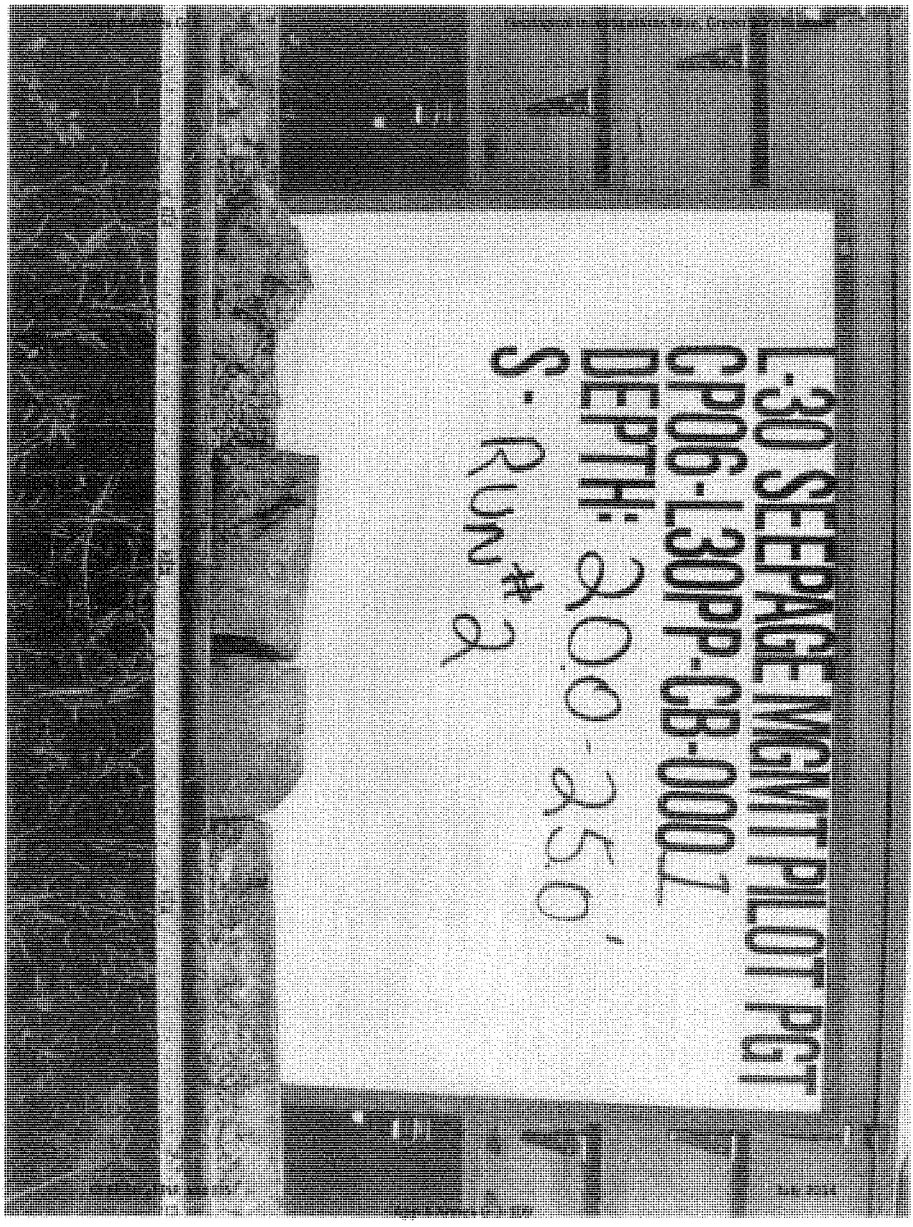
7. Boring sealed with available sediment.

140# hammer w/30" drop used with 2.0' split spoon (1-3/8" I.D. x 2" O.D.).

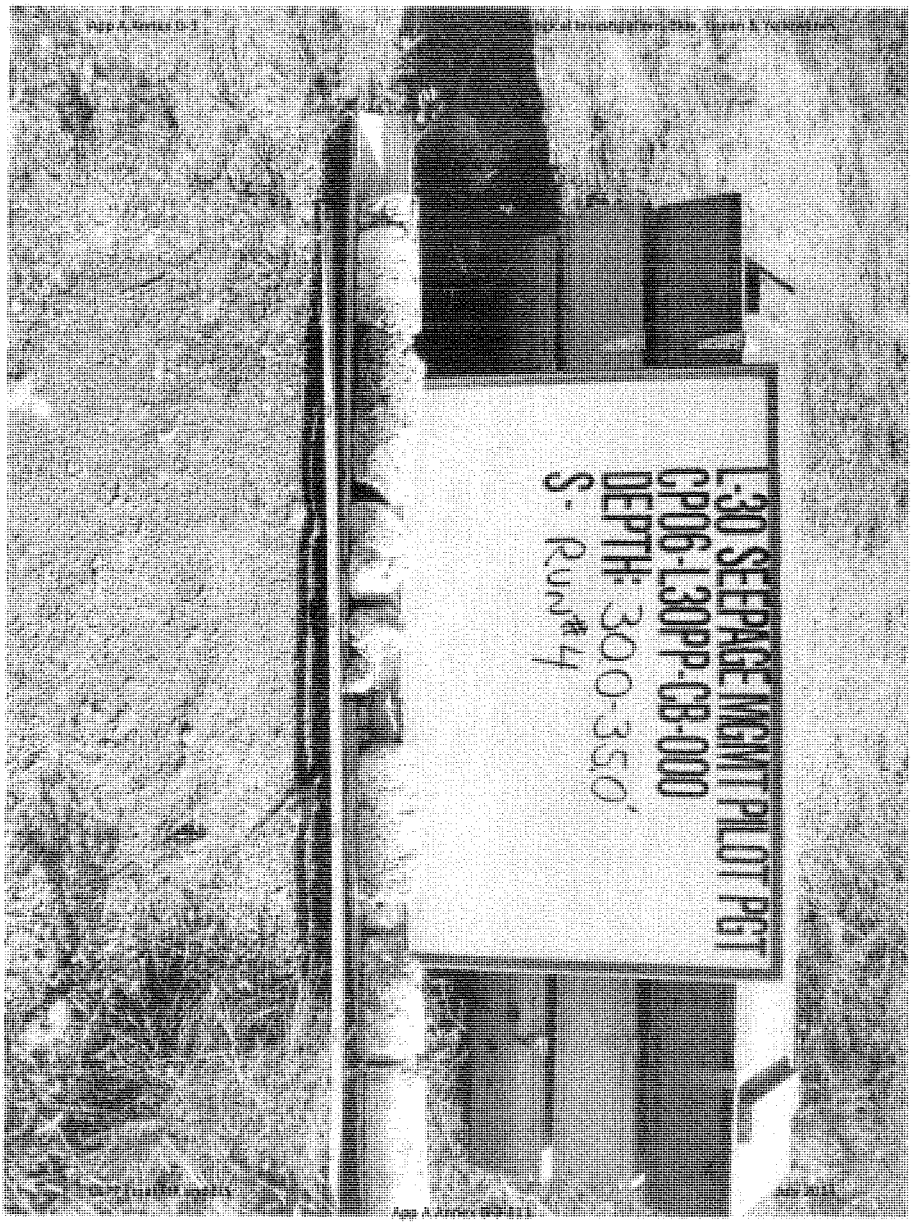
Abbreviations:
WOH = Weight of Hammer.
DT = Drill Time.
HP = Hydraulic Pressure.
DFR = Drill Fluid Return.

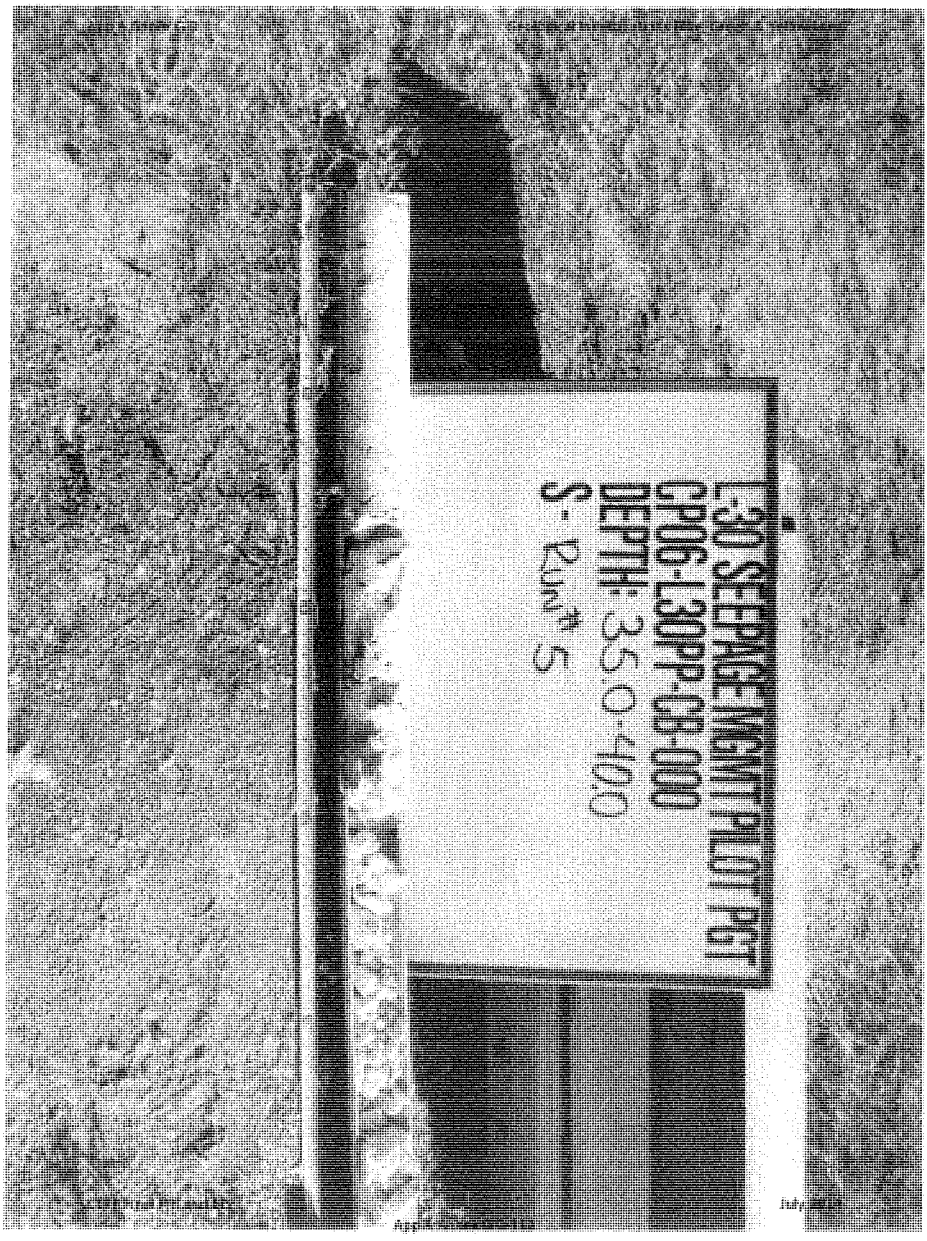
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L30 SEEPAGE MGMT PILOT PRJ
CROSS-L30PP-CR-0007
DEPTH: 1+13.300
S. Run #7


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-GB-0007
DEPTH: 200-250'
S. RIM


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-000
DEPTH: 250-300'
S. RUN #3


L30 SEEPAGE MGMT PILOT PGT
GP06-L30PP-06-000
DEPTH: 300-350'
S-Rec #47


E-3&D SEEPAGE MGMT PILOT PGT
CPOG-130P-0-00-000
DEPTH: 350-400
S. Run #5

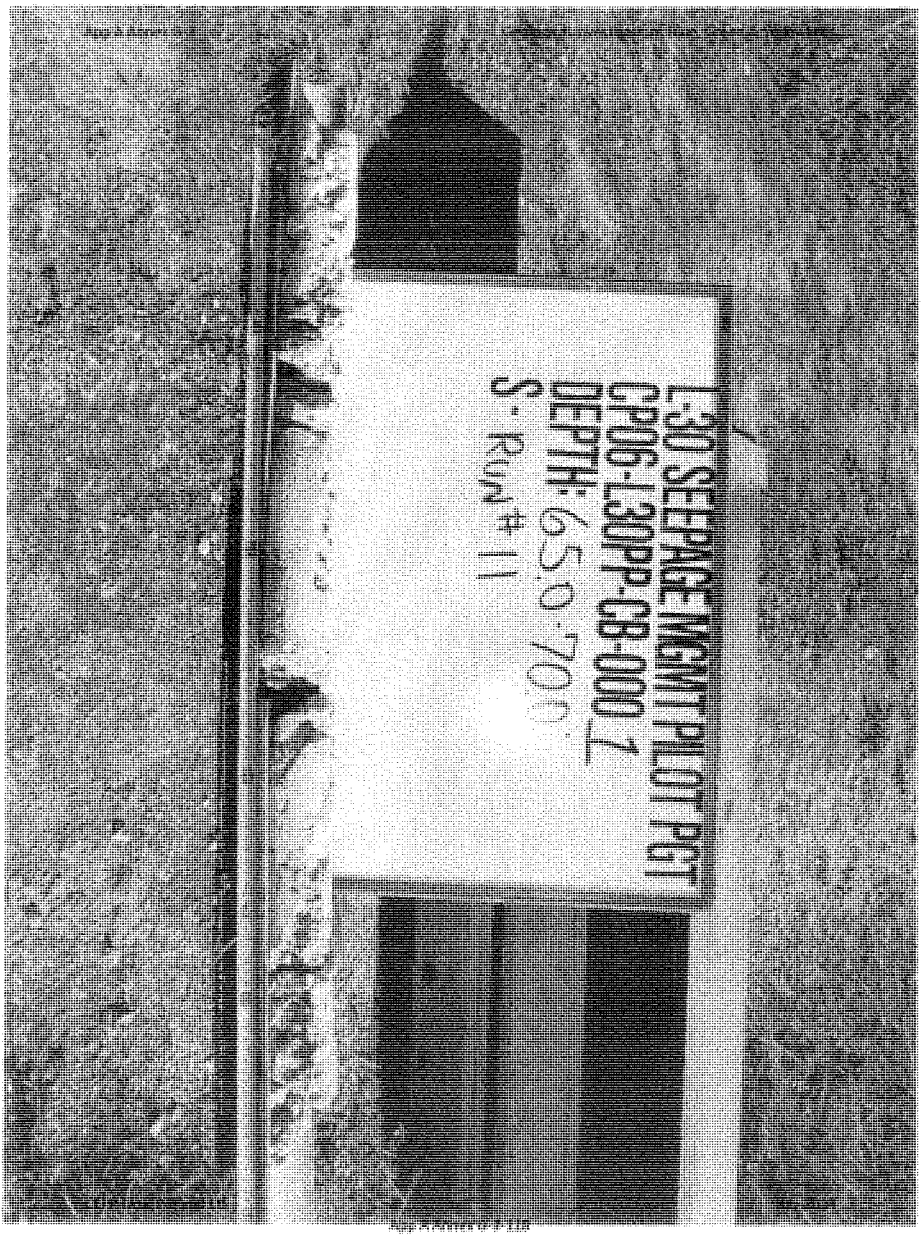
L30 SEEPAGE MGMT PILOT PGT
GP06-L30PP-CB-000
DEPTH: 400'-450'
S. Run #6

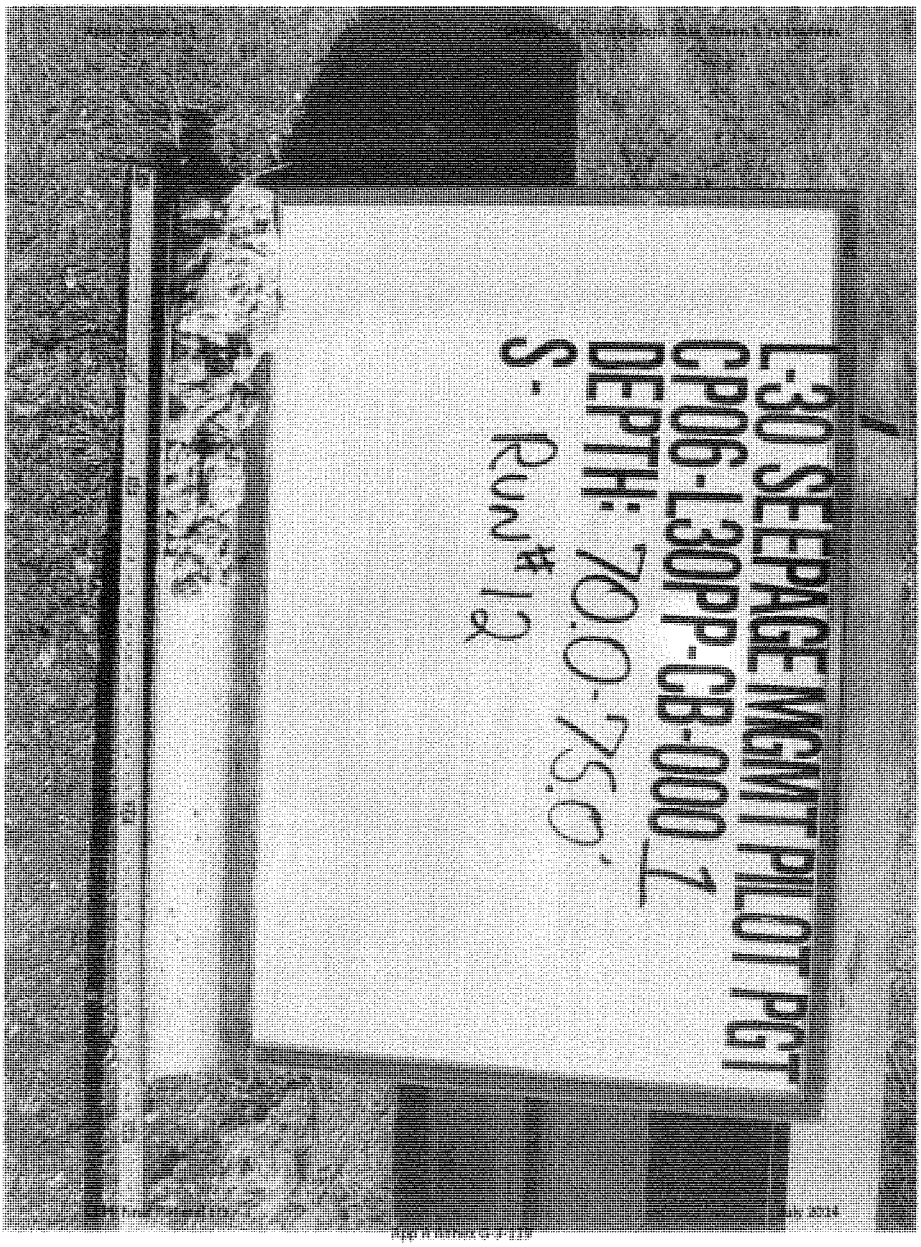
L-30 SEEPAGE MGMT PILOT PGT
CPOG-L30PP-CB-0007
DEPTH: 45.0-65.0'
S- Panel #7

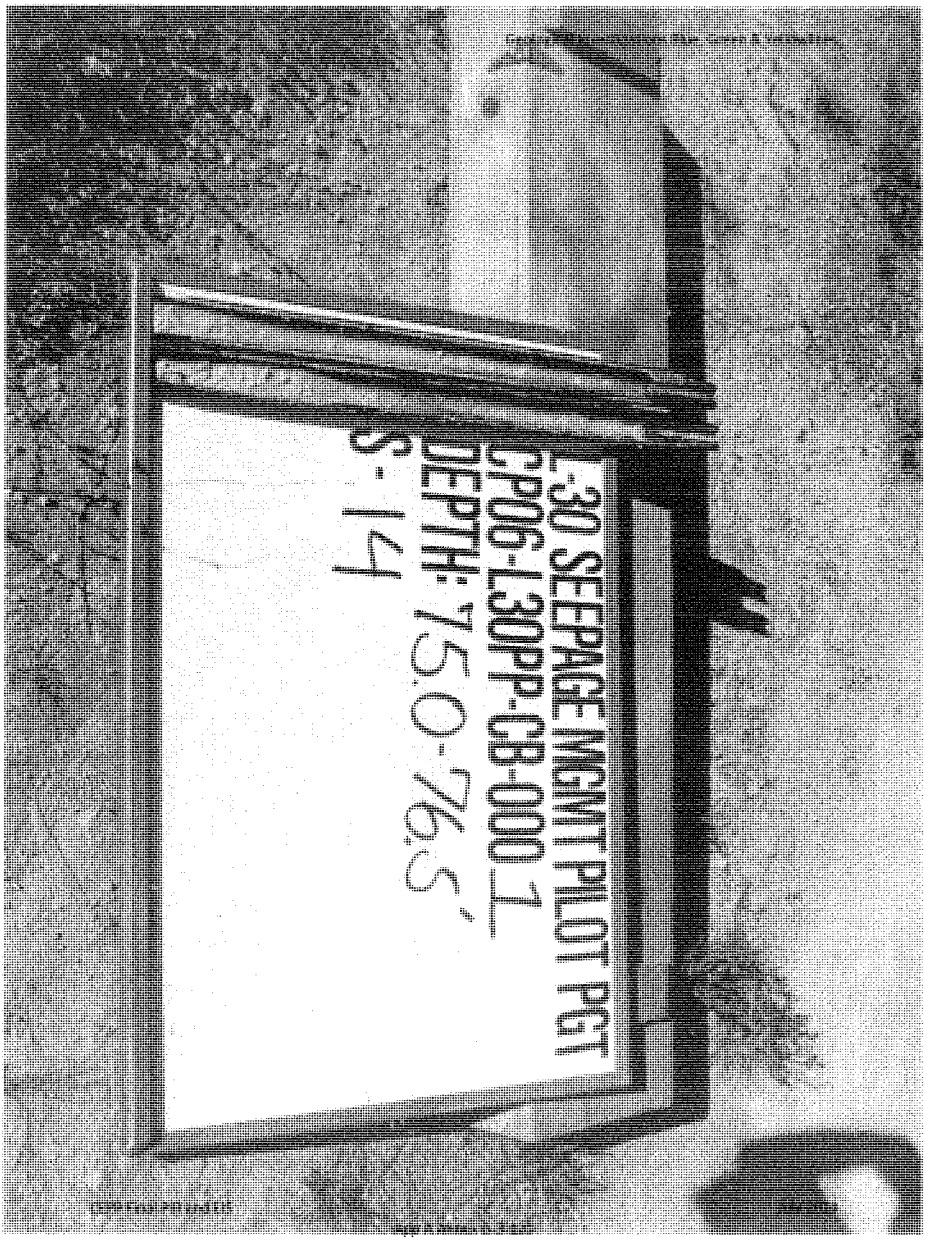
L-30 SEEPAGE MGMT PILOT PGT
CPG6-L30PP-CB-0007
DEPTH: 500-550'
S. Run #3

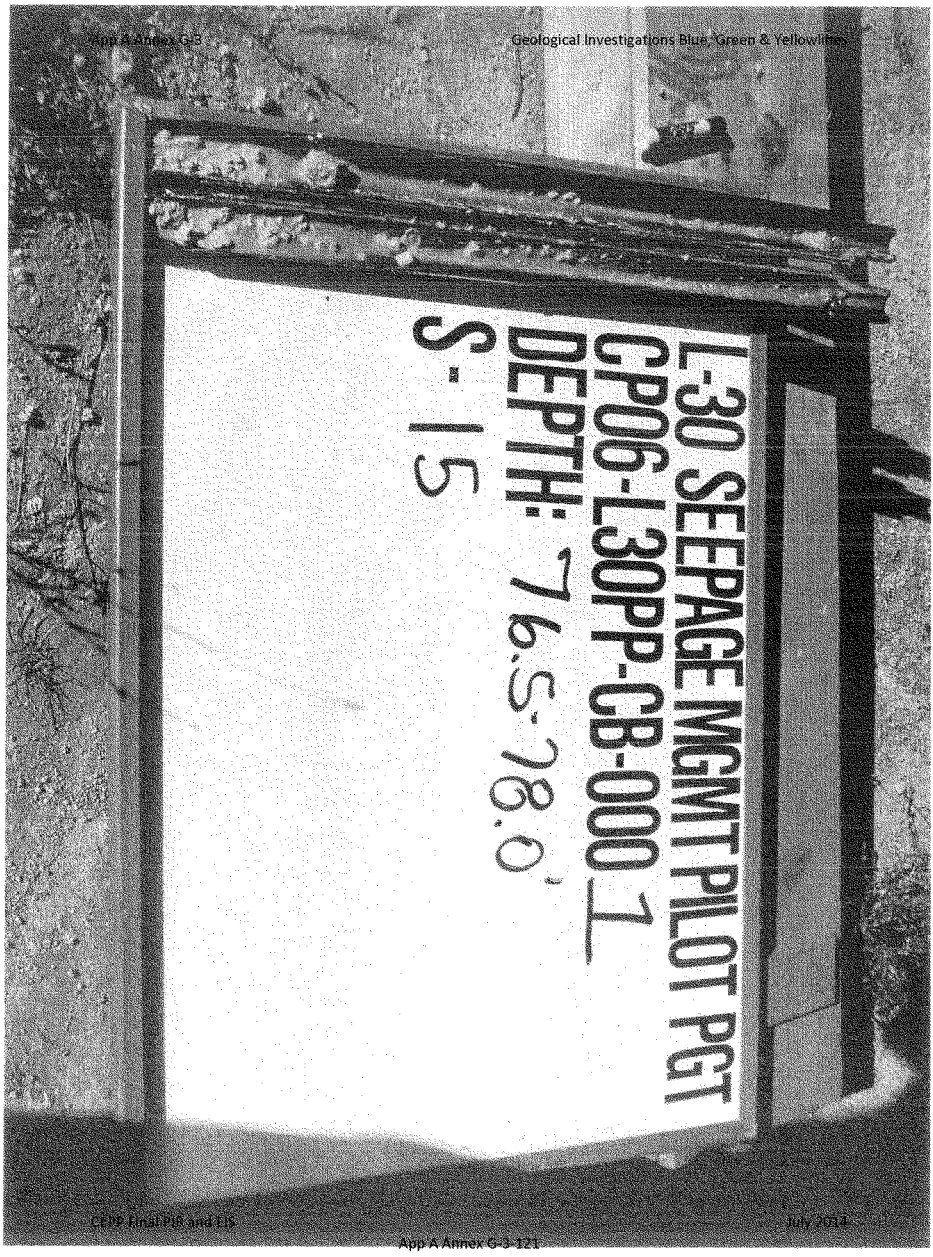

L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-000
DEPTH: 550-600'
S. Reach

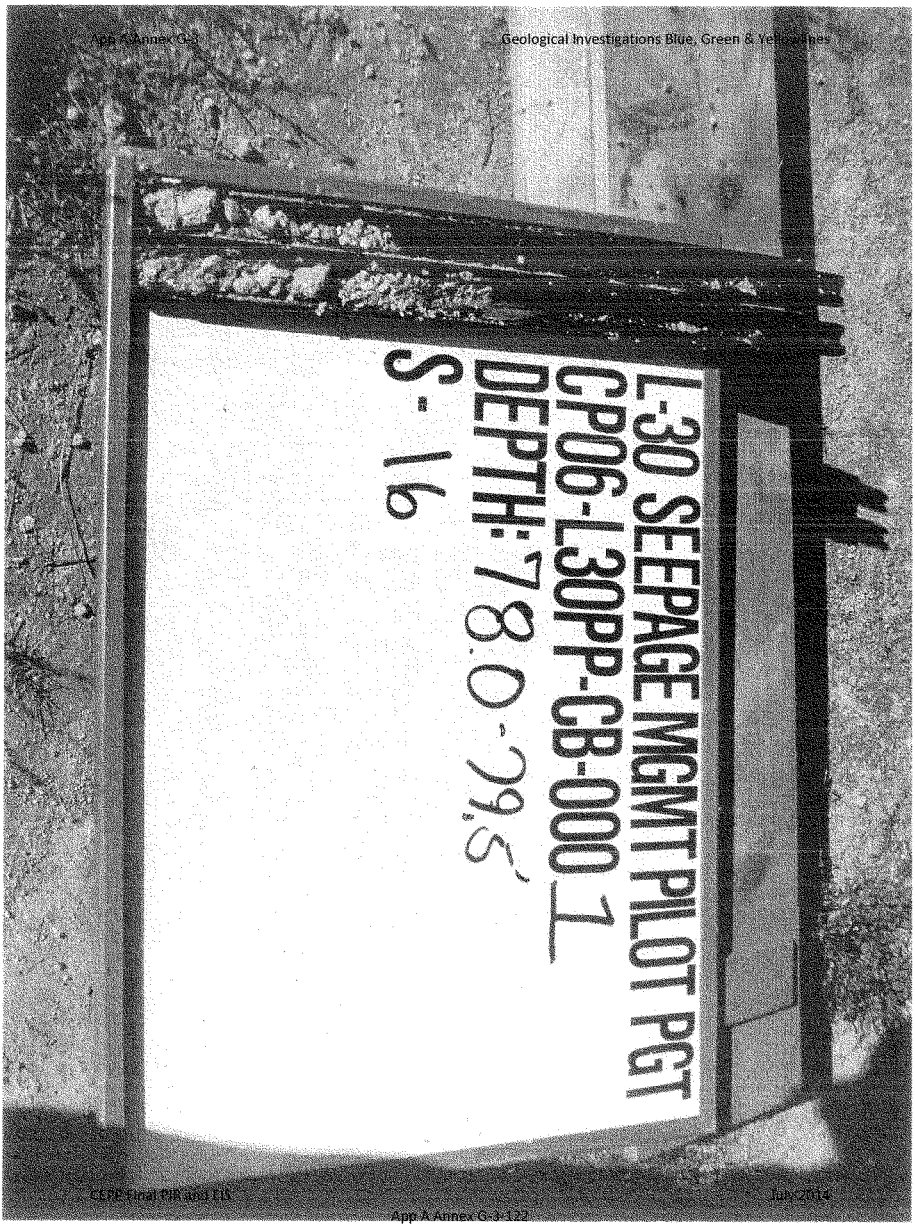
E30 SEEPAGE MGMT PLOT PGT
CP06-E30PP-GB-0001 7
DEPTH: 600-650'
S. Run #10

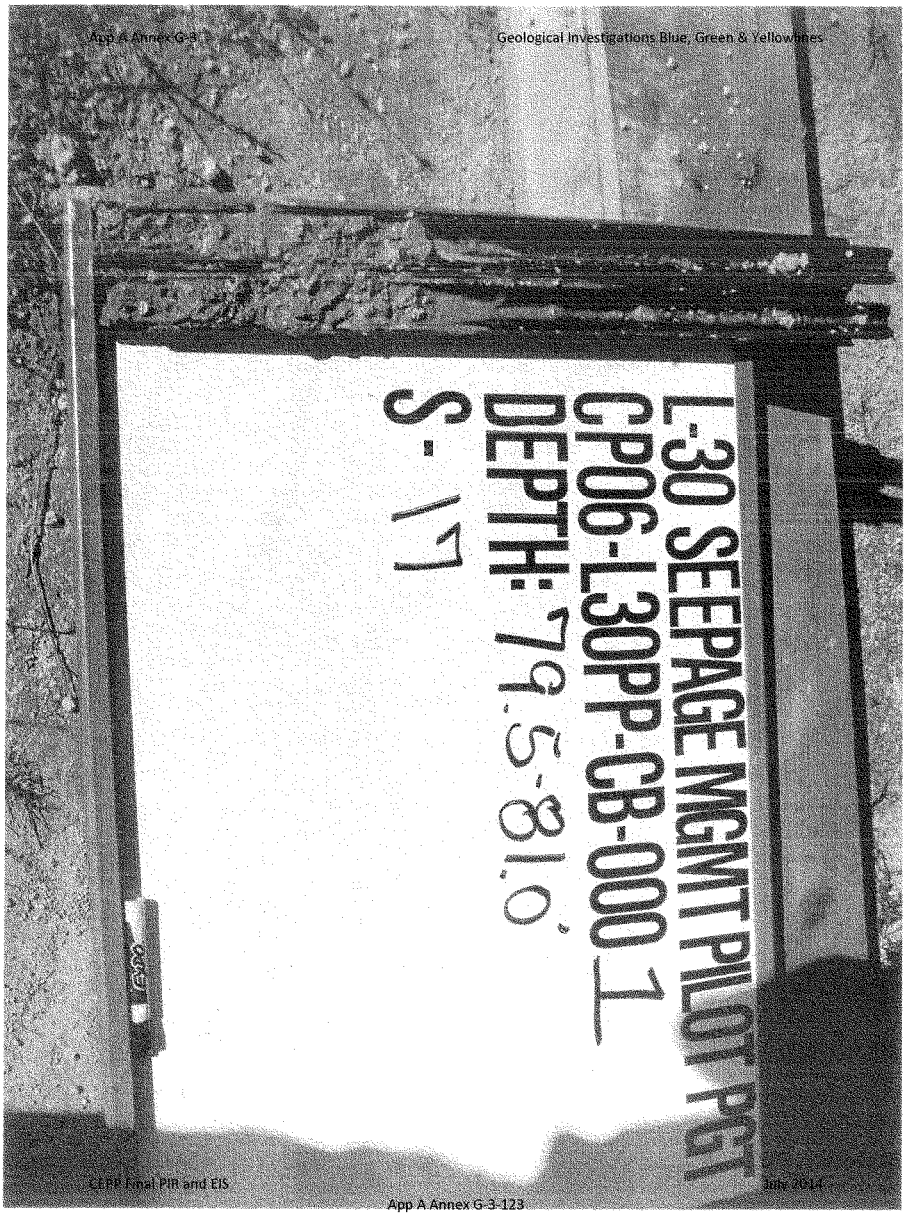

L-30 SEEPAGE MGMT PILOT PROJ
CP06-L30PP-06-0007
DEPTH: 6.5'-7.0'
S. Row #11


L-30 SEEPAGE MGMT PILOT PGT
SPO6-L30PP-CB-0007
DEPTH: 70.0-75.0'
S. Run #13

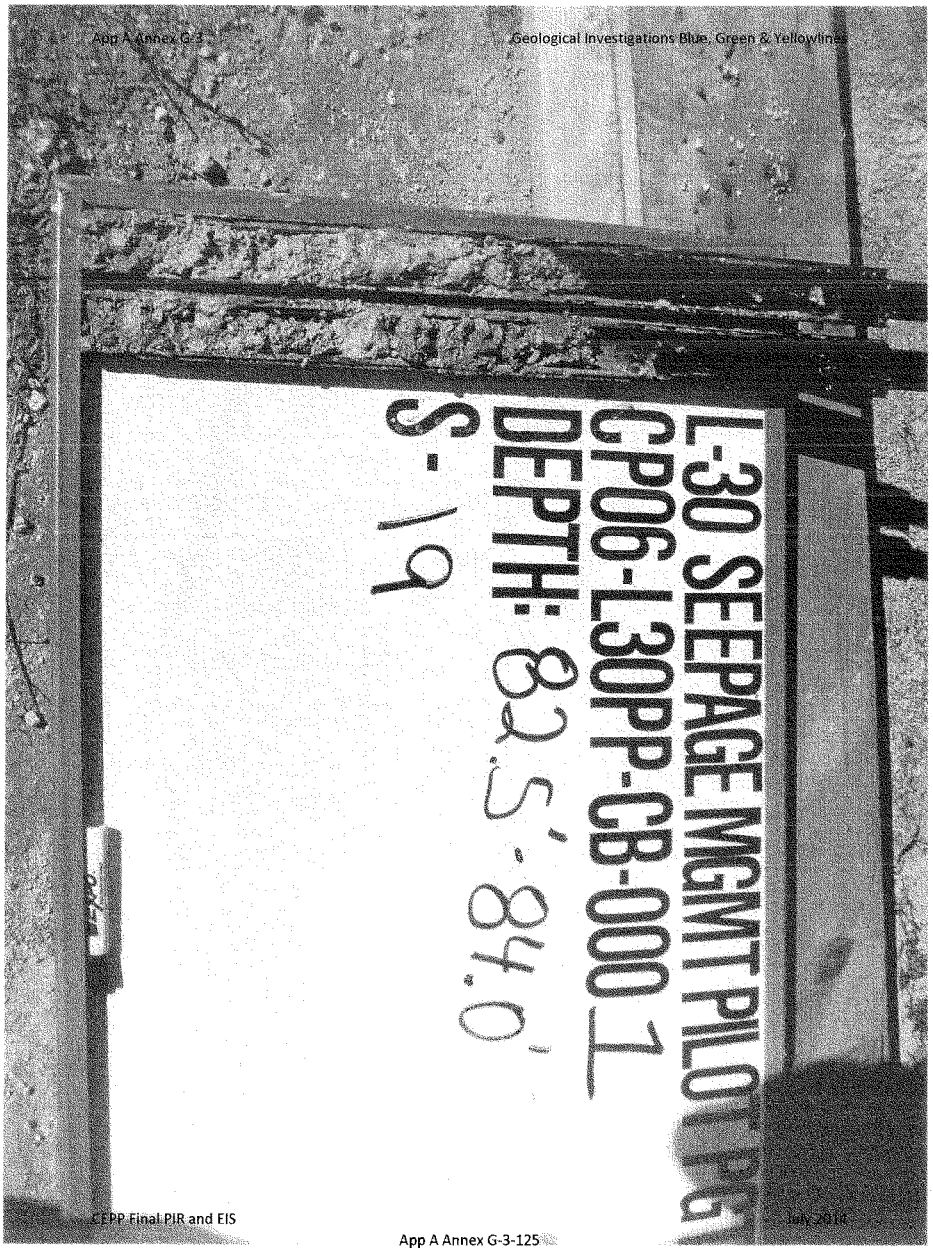

L-30 SEEPAGE MGMT PILOT PGT
CP06-L30P-CB-0001_1
DEPTH: 75.0-76.5'
S-14


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0001
DEPTH: 76.5-78.0'
S- 15


App A Annex G-3
Geological Investigations Blue, Green & Yellow Lines
L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0001
DEPTH: 78.0-79.5
S-16
CERP Final PIR and EIS
App A Annex G-3 122
July 2014

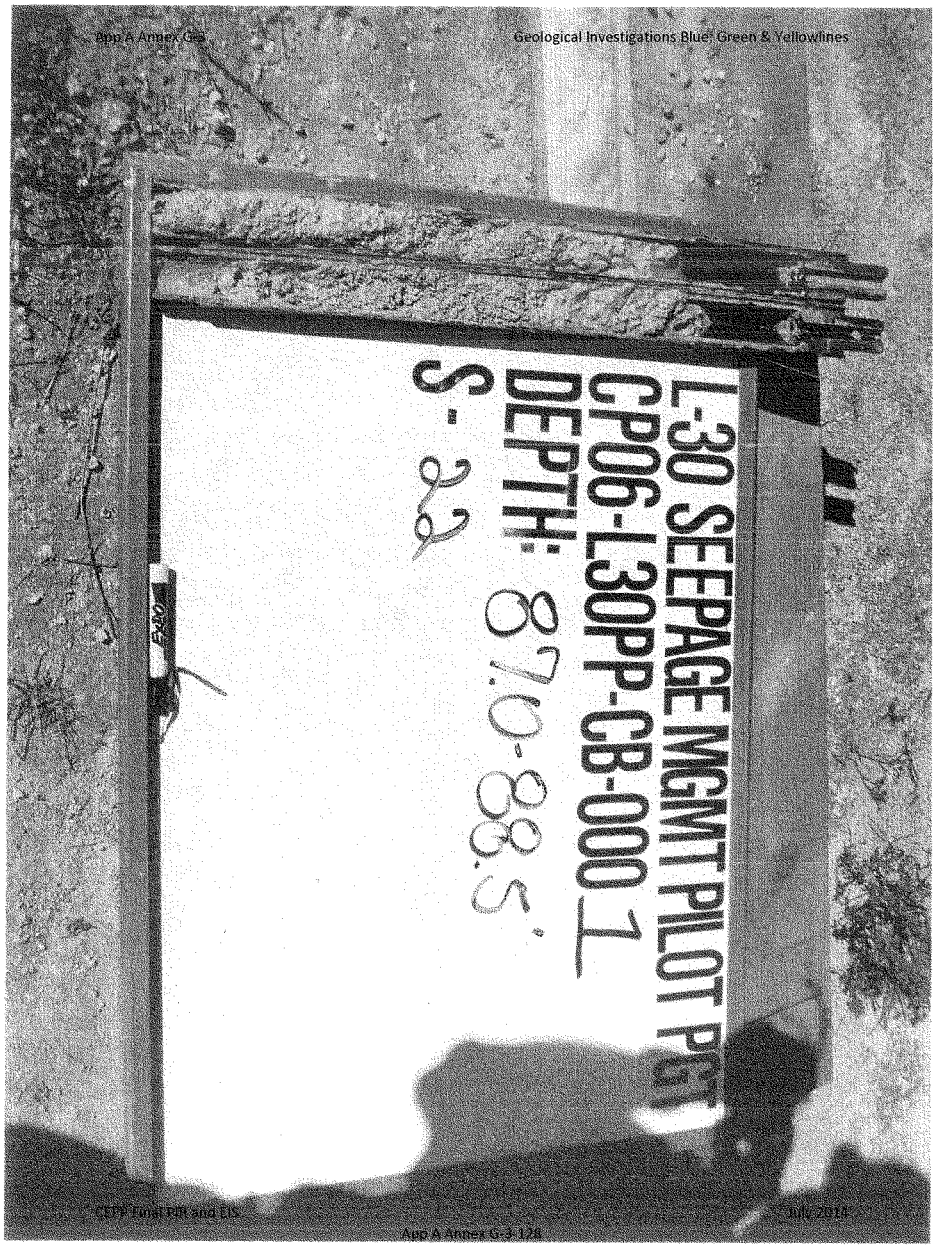

L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0001
DEPTH: 79.5-81.0'
S-11

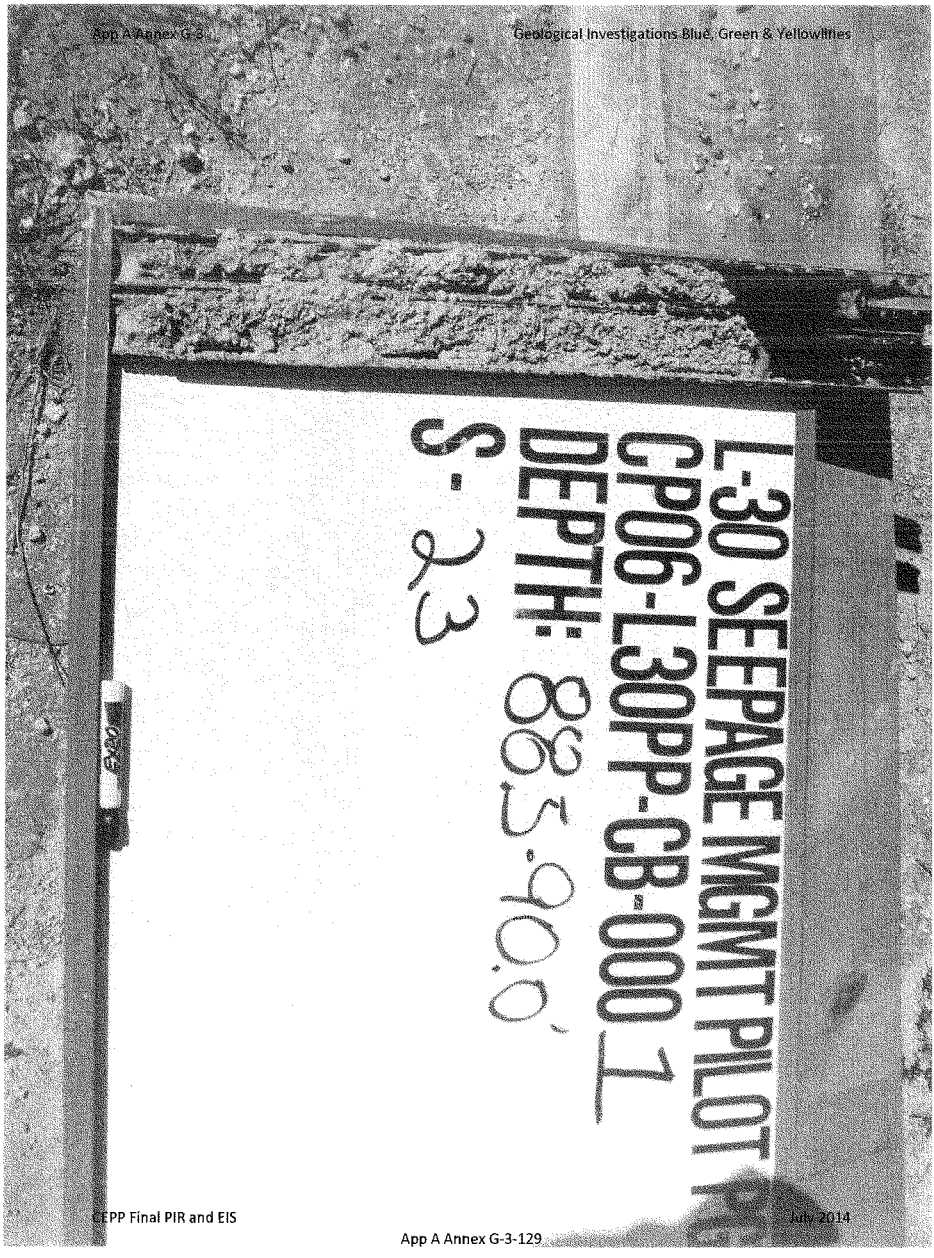

L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0001
DEPTH: 81.0-82.5'
S- 18

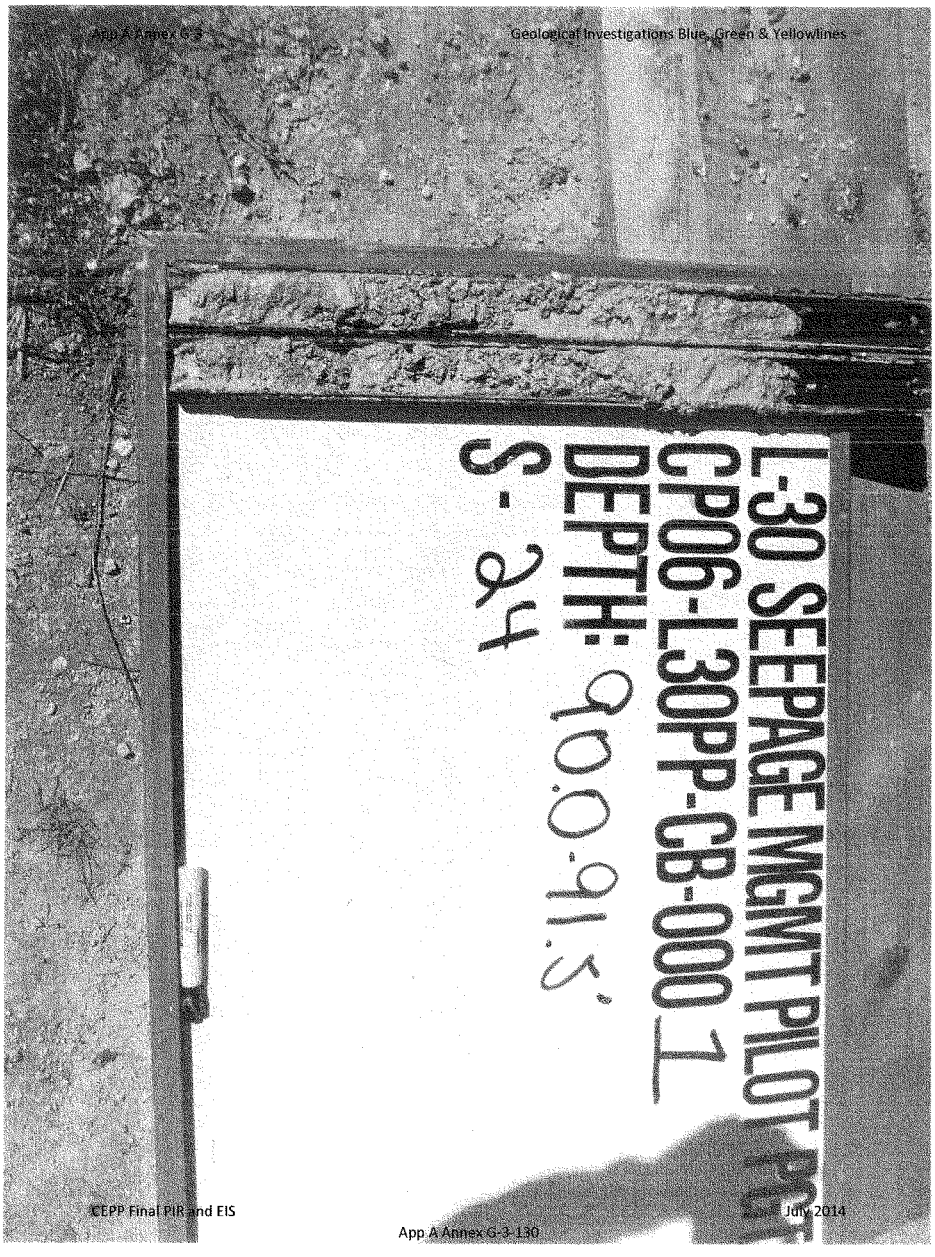

L-30 SEEPAGE MGMT PILOT
CP06-L30PP-CB-0001
DEPTH: 82.5'-84.0'
S-19

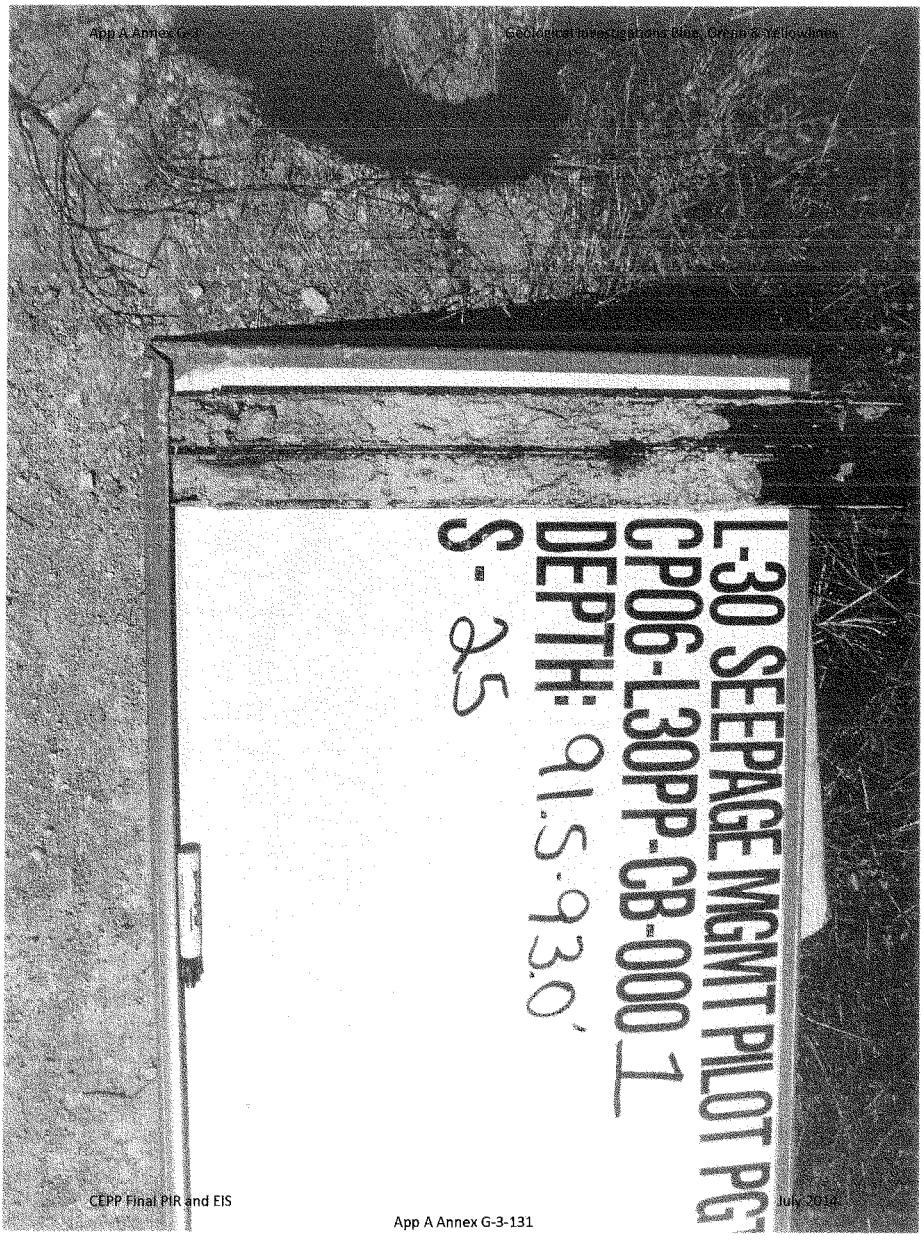

L-30 SEEPAGE MGMT PILOT PROJ
CP06-L30PP-CB-0001
DEPTH: 84.0-85.0
S. 20

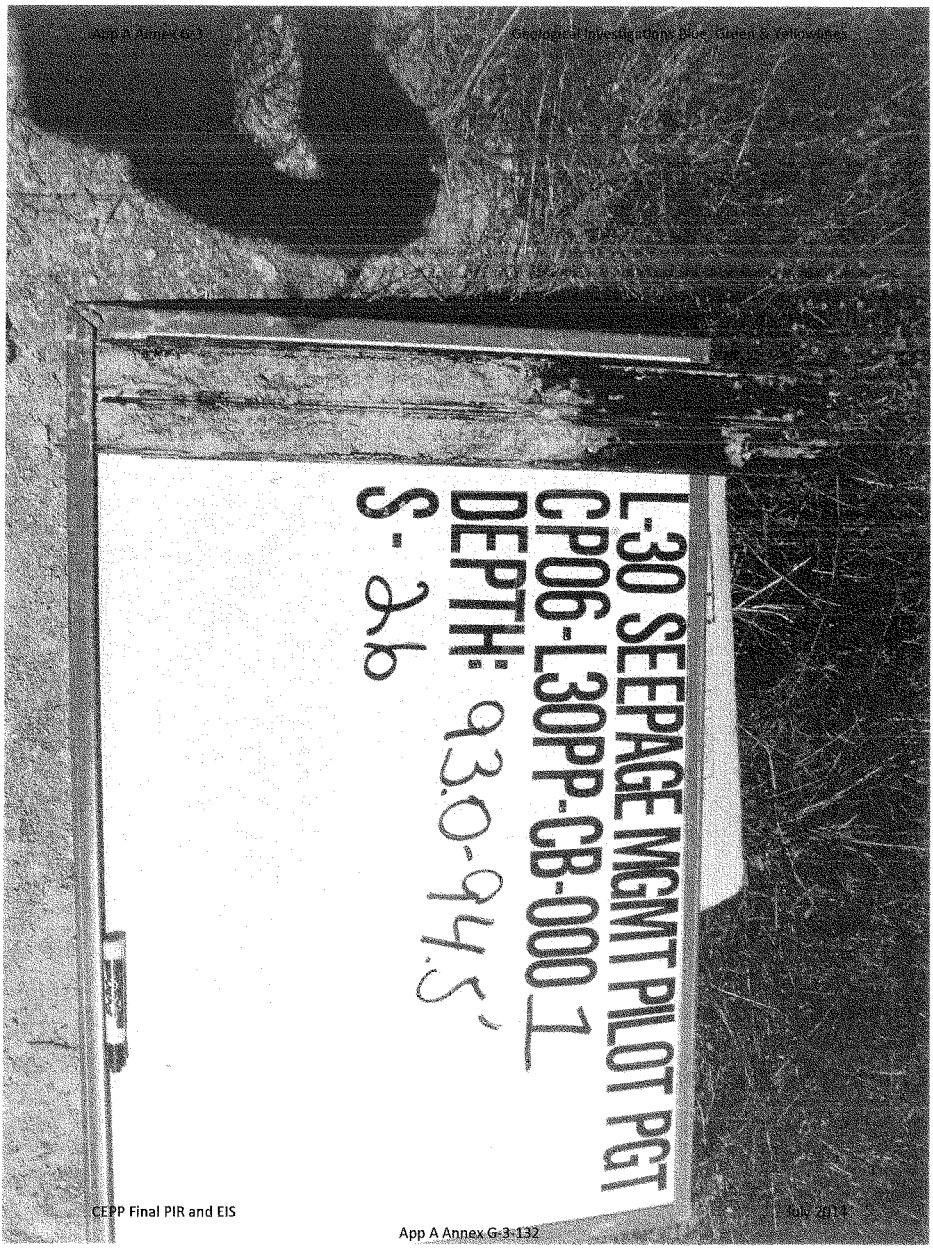

L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0001
DEPTH: 870-885
S-21


App A Annex Geo
Geological Investigations Blue, Green & Yellowlines
L-30 SEEPAGE MGMT PILOT PGM
CP06-L30PP-CB-0001
DEPTH: 87.0-88.5'
S.
&
CERP Final PIR and EIS
App A Annex G.3.126
July 2014

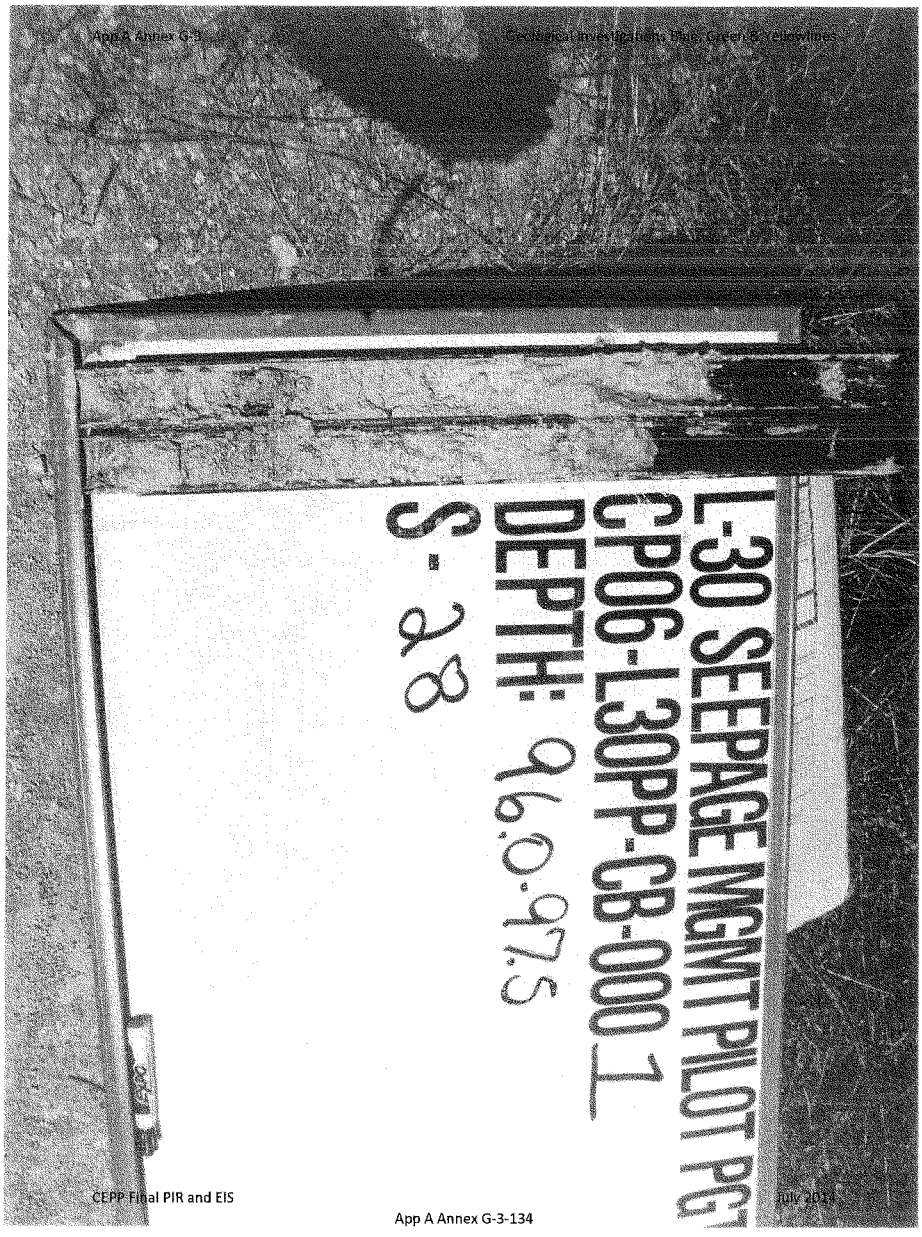

L-30 SEEPAGE MGMT PILOT
CP06-L30PP-CB-0001
DEPTH: 865.00'
S.23


L-30 SEEPAGE MGMT PILOT PR
CP06-L30PP-CB-0001
DEPTH: 90.0-91.5'
S-24


App A Annex G-3
Geological Investigations Bldg, Oregon & Yellowtail
L-30 SEEPAGE MGMT PILOT PG
GP06-L30PP-CB-0001
DEPTH: 91.5-93.0'
S: 95


App A Annex G-3
Geological Investigations Blue, Green & Yellow Lines
L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0001
DEPTH: 930-945'
S-26
CEPP Final PIR and EIS
App A Annex G-3-132
July 2014


App A Annex G-3
Geological Investigations Blue, Green & Yellow Lines
L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0001
DEPTH: 94.5-96.0'
S-27
CEPP Final PIR and EIS
App A Annex G-3-133
July 2014


L-30 SEEPAGE MGMT PILOT PG
CP06-L30PP-CB-0001
DEPTH: 96.0-97.5
S-28


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0001
DEPTH: 975-990'
S-99


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0001
DEPTH: 990-1005'
S: 30


App A Annex G-3
Geotechnical Investigations Blue, Green & Yellowlines
L-30 SEEPAGE MGMT PILOT PGT
GP06-L30PP-CB-0001
DEPTH: 100.5-102.0
S-31
CERP Final PIR and EIS
App A Annex G-3 137
July 2014


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0001
DEPTH: 1020-1035'
S-32


App A Annex G-3
Geotechnical Investigations, Blue, Green & Yellowlines
L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0001
DEPTH: 1035'-1050'
S. 33
CCPP Final PIR and EIS
App A Annex G-3-139
July 2014

SOILS TEST CORE BORING NUMBER "CP06-L30PP-CB-0002"

Miami-Dade County, Florida

Boring Designation CP06-L30PP-CB-0002

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 7 SHEETS
1. PROJECT: L-30 Seepage Management Pilot Project Top Of Levee L-30 (Center of Roadway)		9. SIZE AND TYPE OF BIT: See Remarks 10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
2. BORING DESIGNATION: CP06-L30PP-CB-0002	LOCATION COORDINATES: X = 823,753 Y = 522,044	11. MANUFACTURER'S DESIGNATION OF DRILL: CME 55 Truckrig	☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Challenge Engineering & Testing, Inc.	CONTRACTOR FILE NO.: 2006D30	12. TOTAL SAMPLES: 33	DISTURBED: 33 / UNDISTURBED (UD): 0
4. NAME OF DRILLER: Adam Benson		13. TOTAL NUMBER CORE BOXES: 4	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG. FROM VERTICAL	BEARING	14. ELEVATION GROUND WATER: 5.0 Ft.
			15. DATE BORING: STARTED 10-06-06 / COMPLETED 10-17-06
6. THICKNESS OF OVERBURDEN: N/A			16. ELEVATION TOP OF BORING: 17.5 Ft.
7. DEPTH DRILLED INTO ROCK: N/A			17. TOTAL RECOVERY FOR BORING: 65 %
8. TOTAL DEPTH OF BORING: 109.0 Ft.			18. SIGNATURE AND TITLE OF INSPECTOR: Bob Momberger, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	ROD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
17.5	0.0		L-30 Levee Fill Material				17.5		
							Advanced Boring w/ tricone roller bit		

0 5 10 15

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation CP06-L30PP-CB-0002

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 2 OF 7 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 823,753 Y = 522,044	ELEVATION TOP OF BORING: 17.5 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR GD	REMARKS	BLOWS PER 6 IN. N-VALUE
0.2	17.3						Advanced Boring w/ tricone roller bit 0.2	
-2.5	20.0		LIMESTONE, oolitic, sparsely fossiliferous, soft, moderately weathered, fine-grained, thin bedding, vuggy, Ft. Thompson Formation, 2.5Y 8/2 pale yellow	81	1	RQD 20	4 x 5-1/2" Diamond Impregnated Bit DT = 1 mins HP = 250 psi DFR = 50 % -2.5	
-5.5	23.0	Moderately Weathered	LIMESTONE, hard, moderately weathered, fine-grained, thick bedding, pitted, 5Y 8/1 white At El. -4.0 Ft., 5Y 7/3 pale yellow	100	2	RQD 85	4 x 5-1/2" Diamond Impregnated Bit DT = 4 mins HP = 250 psi DFR = 25 % -7.5	
-12.5	30.0	Slightly Weathered	LIMESTONE, fossiliferous, moderately hard, slightly weathered, aphanitic, thick bedding, vuggy, 5Y 8/2 pale yellow At El. -9.5 Ft., thin bedding, 5Y 8/1 white	60	BOX 1 3	RQD 10	4 x 5-1/2" Diamond Impregnated Bit DT = 3 mins HP = 250 psi DFR = 0 % -12.5	
-14.5	32.0		SAND, silty, soft, mostly subangular fine-grained sand-sized carbonate, strong reaction with HCl, wet, 2.5Y 8/2 pale yellow (SM)					
		Moderately Weathered	LIMESTONE, fossiliferous, moderately hard, moderately weathered, fine-grained, thin bedding, vuggy, 5Y 8/1 white At El. -17.0 Ft., 5Y 8/4 pale olive	60	BOX 2	RQD 0	4 x 5-1/2" Diamond Impregnated Bit DT = 4 mins HP = 250 psi DFR = 0 % -17.5	

SAJ FORM 1836-A
JUN 02

Boring Designation CP06-L30PP-CB-0002

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 3 OF 7 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. FL) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 823,753 Y = 522,044	ELEVATION TOP OF BORING: 17.5 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	RQD OR UD	REMARKS	BLOWS/0.5 FT.	N-VALUE
		Moderately Weathered	From El. -20.5 to -31.5 Ft., unweathered, aphanitic, thin bedding, pitted, 5Y 8/1 white	60	5	RQD 25	4 x 5-1/2" Diamond Impregnated Bit DT = 3 mins HP = 250 psi DFR = 0 %		
							-22.5		
				60	BOX NO. 6	RQD 0	4 x 5-1/2" Diamond Impregnated Bit DT = 5 mins HP = 250 psi DFR = 0 %		
							-27.5		
		Unweathered	From El. -31.5 to -37.5 Ft., soft, unweathered, aphanitic, thin bedding, pitted, clay filled pits	66	7	RQD 0	4 x 5-1/2" Diamond Impregnated Bit DT = 5 mins HP = 250 psi DFR = 0 %		
							-32.5		
		Unweathered		60	BOX NO. 8	RQD 25	4 x 5-1/2" Diamond Impregnated Bit DT = 6 mins HP = 250 psi DFR = 0 %		
							-37.5		

35 40 45 50 55

SAJ FORM 1836-A
JUN 02

Boring Designation CP06-L30PP-CB-0002

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 4 OF 7 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 823,753 Y = 522,044	ELEVATION TOP OF BORING: 17.5 Ft	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR COR	REMARKS	BLOWS/ 0.5 FT.	N-VALUE	
		Mod Weathered	From El. -37.5 to -39.5 Ft., moderately hard, moderately weathered, aphanitic, thin bedding, vuggy, 5Y 7/2 light gray							55
		Unweathered	From El. -39.5 to -43.5 Ft., soft, unweathered, aphanitic, thin bedding, pitted, clay filled pits, 5Y 8/1 white	25	9	RQD 0	4 x 5-1/2" Diamond Impregnated Bit DT = 4 mins HP = 250 psi DFR = 0 %			
							-42.5			60
			From El. -43.5 to -46.0 Ft., moderately hard, moderately weathered, aphanitic, thin bedding, vuggy, sand filled vugs, 5Y 7/3 pale yellow	20	BOX 0	RQD 0	4 x 5-1/2" Diamond Impregnated Bit DT = 6 mins HP = 250 psi DFR = 0 %			
			From El. -46.0 to -51.5 Ft., moderately weathered, aphanitic, thin bedding, pitted, clay filled pits, 10YR 7/2 light gray							
							-47.5			65
		Mod Weathered to Unweathered		80	11	RQD 8	4 x 5-1/2" Diamond Impregnated Bit DT = 6 mins HP = 250 psi DFR = 0 %			
							-52.5			70
		Unweathered	From El. -51.5 to -55.5 Ft., unweathered, aphanitic, medium bedding, vuggy, sand filled vugs, 10YR 8/2 very pale brown							
			From El. -55.5 to -57.5 Ft., moderately weathered, fine-grained, thick bedding, pitted, sand filled pits, 2.5Y 8/1 gray	90	BOX 4'	RQD 60	4 x 5-1/2" Diamond Impregnated Bit DT = 3 mins HP = 250 psi DFR = 0 %			
-57.5	75.0	Mod Weathered					-57.5			75

SAJ FORM 1836-A
JUN 02

Boring Designation CP06-L30PP-CB-0002

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 5 OF 7 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 823,753 Y = 522,044	ELEVATION TOP OF BORING: 17.5 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC. %	BOX OR SAMPLE NO.	ROD OR CORE NO.	REMARKS	BLOWS/0.5 FT.	N-VALUE
-61.5	79.0	Slightly Weathered	LIMESTONE, soft, slightly weathered, aphanitic, 5Y 7/3 pale yellow	0	BOX 4C	ROD 0	4 x 5-1/2" Diamond Impregnated Bit DT = 2 mins HP = 250 psi DFR = 0 %		
-62.5	80.0	Very Hard	LIMESTONE, fossiliferous, soft, slightly weathered, aphanitic, pitted, sand filled pits, 5Y 7/3 pale yellow	20	14		SPT Sampler	WOR 0 0	0
-68.5	86.0		SHELL, mostly angular coarse-grained sand-sized shell up to 1/2", little clay, strong reaction with HCl, wet, Pinecrest Sand Formation, 2.5Y 7/1 light gray At El. -64.5 Ft., some coarse gravel-sized limestone up to 1"	40	15		SPT Sampler	7 12 11	23
				97	16		SPT Sampler	7 14 14	28
				73	17		SPT Sampler	8 17 16	33
-70.0	87.5		SAND, clayey, nonplastic, soft, mostly fine-grained sand-sized carbonate, little clay, strong reaction with HCl, wet, 2.5Y 7/1 light gray (SC)	100	18		SPT Sampler	7 8 8	16
-74.5	92.0		SHELL, mostly angular coarse-grained sand-sized shell up to 1/4", some coarse-grained sand-sized limestone up to 1/2", little clay, strong reaction with HCl, wet, 2.5Y 6/1 gray At El. -73.5 Ft., nonplastic, mostly angular medium-grained sand-sized shell up to 1/4", little fine to medium-grained sand-sized carbonate, strong reaction with HCl, wet, 2.5Y 6/1 gray	50	19		SPT Sampler	12 14 15	29
				77	20		SPT Sampler	12 12 14	26
				90	21		SPT Sampler	14 8 10	18
				90	22		SPT Sampler	10 8 7	15
			CLAY, lean, medium plasticity, soft, mostly clay, some shell up to 1/4", little fine-grained sand-sized carbonate, strong reaction with HCl, wet, 2.5Y 5/1 gray (CL) At El. -76.5 Ft., some fine-grained sand-sized quartz, little coarse-grained sand-sized shell, strong reaction with HCl,	90	23		SPT Sampler	5 7 7	14
				80	24		SPT Sampler	6 5	

SAJ FORM 1836-A
JUN 02

Boring Designation CP06-L30PP-CB-0002

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 6 OF 7 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 823,753 Y = 522,044	ELEVATION TOP OF BORING: 17.5 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE #	ROD OR CORE	REMARKS	BLOWS/ 0.5 FT.	N VALUE
			wet, 10Y 6/1 greenish gray	90	24		-78.0 SPT Sampler	5	10
-78.5	96.0							15	
			SAND, silty, very soft, mostly fine-grained sand-sized quartz, little silt, little coarse-grained sand-sized shell up to 1/4", strong reaction with HCl, wet, 10Y 7/1 light greenish gray (SM)	67	25		SPT Sampler	15	23
							-79.5	8	
				47	26		SPT Sampler	7	
								14	28
-81.0	98.5						-81.0	14	
			SHELL, mostly angular fine to coarse gravel-sized shell up to 3/4", little fine-grained sand-sized quartz, little sand to gravel-sized limestone up to 1/2", few silt, strong reaction with HCl, wet, 10Y 7/1 light greenish gray	90	27		SPT Sampler	7	
			At El. -82.5 Ft., few fine-grained sand-sized quartz					14	35
							-82.5	21	
				90	28		SPT Sampler	22	
								23	44
							-84.0	21	
				90	29		SPT Sampler	12	
			At El. -85.0 Ft., some fine to medium-grained sand-sized quartz, trace sand to gravel-sized shell up to 3/4"					11	20
							-85.5	9	
				90	30		SPT Sampler	5	
								10	20
-87.5	105.0						-87.0	10	
			SAND, silty, some fine-grained sand-sized quartz, little fine-grained sand-sized carbonate, little sand to gravel-sized shell up to 1/2", strong reaction with HCl, wet, 10Y 6/1 greenish gray (SM)	90	31		SPT Sampler	17	
			At El. -88.5 Ft., few coarse-grained sand-sized limestone up to 1/4"					23	65
							-88.5	42	
				90	32		SPT Sampler	27	
								37	74
							-90.0	37	
				97	33		SPT Sampler	14	
-91.4	108.9							34	71
			LIMESTONE, fossiliferous, moderately hard, coarse-grained, pitted, clay filled pits, 10Y 6/1 greenish gray				-91.5	37	

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.
2. Set 17.5 Ft. of 8" Schedule 40 PVC Pipe Through Center of L-30 Levee To Top of Rock.
3. Boring Drilled/Sampled In Three Phases:
   A. Set Surface Casing.
   B. 4" Wireline Rock Coring To Base Of Rock.
   C. Splitspoon Sampling 30 Ft. Below Base of Rock.

140# hammer w/30" drop used with 2.0' split spoon (1-3/8" I.D. x 2" O.D.).

Abbreviations:
WOR = Weight of Rods.
DT = Drill Time.
HP = Hydraulic Pressure.
DFR = Drill Fluid Return.

SAJ FORM 1836-A
JUN 02

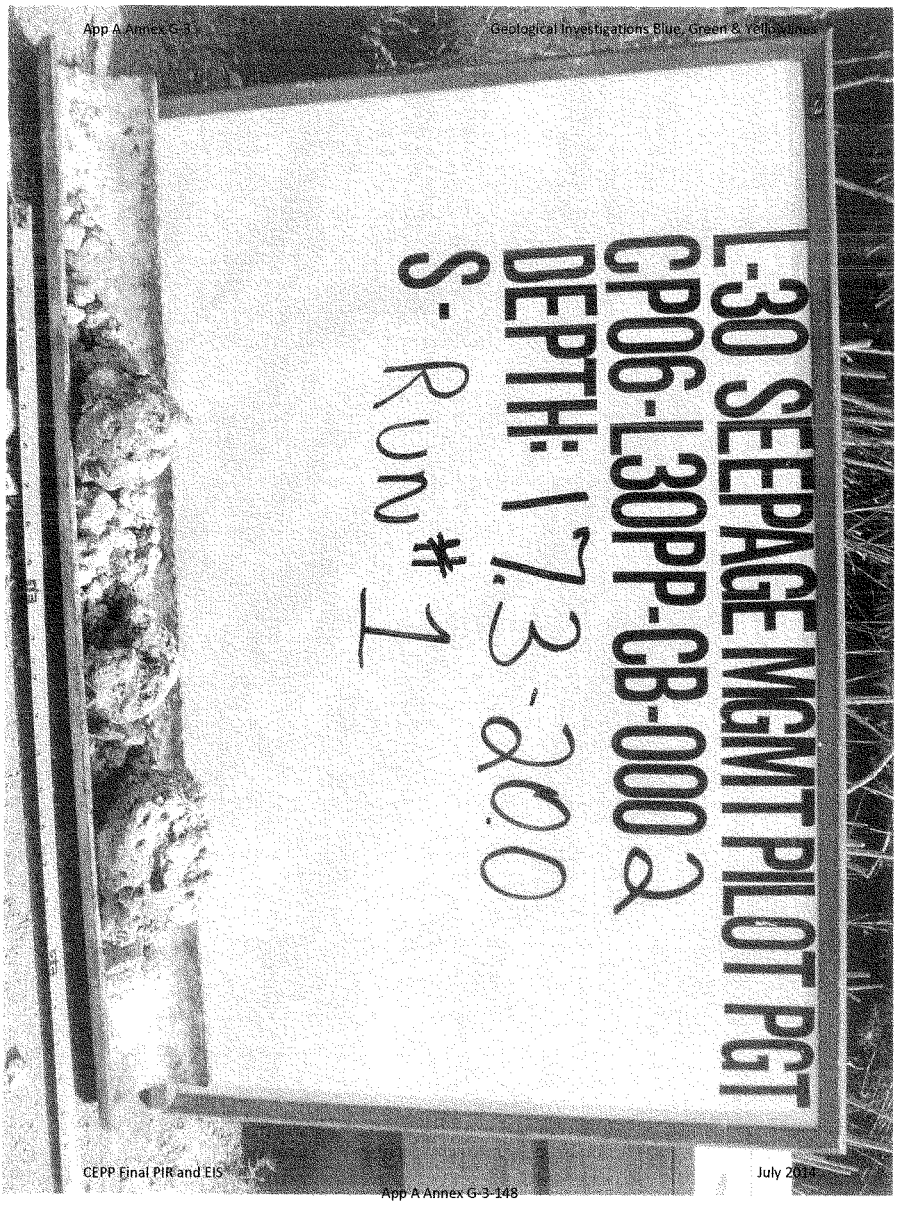
Boring Designation CP06-L30PP-CB-0002

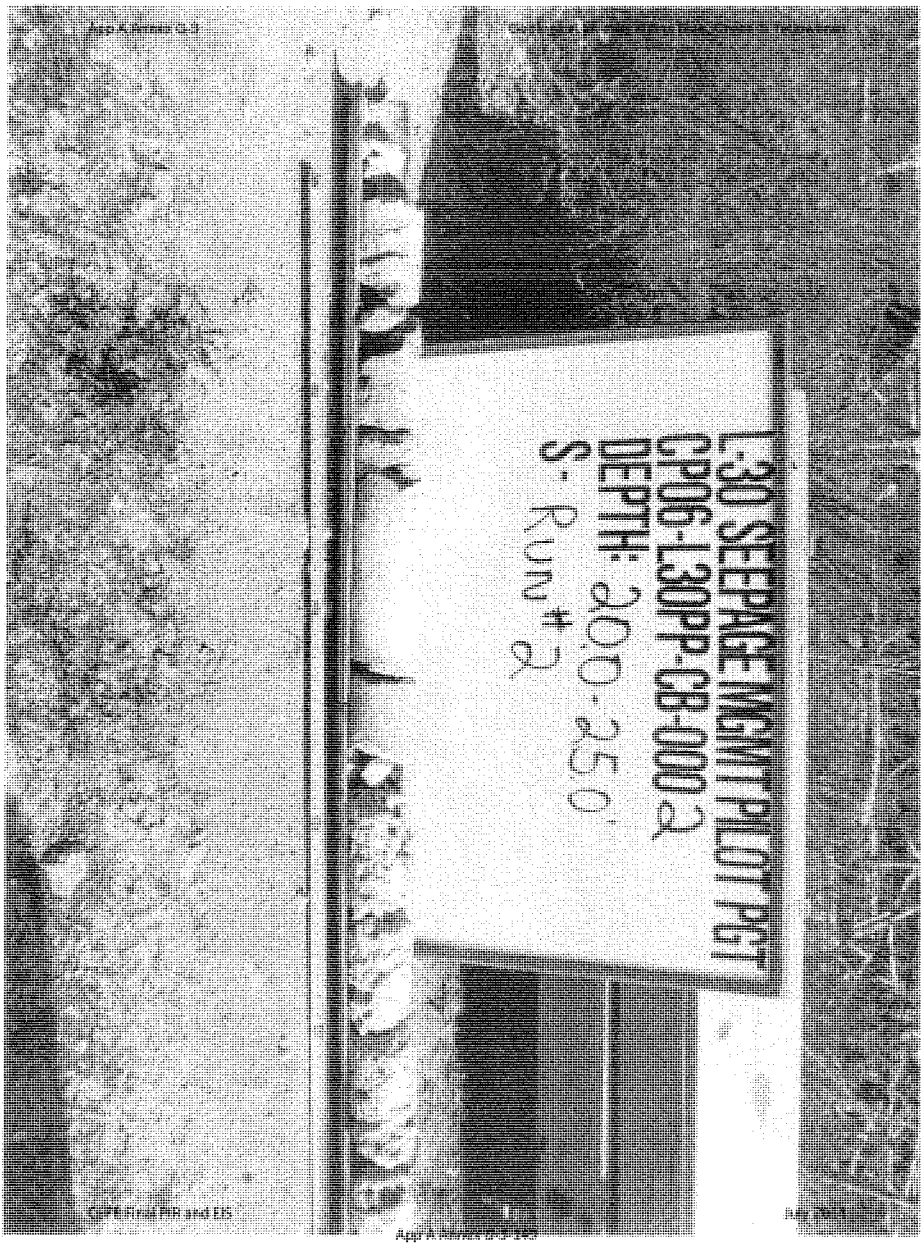
DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 7 OF 7 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 823,753 Y = 522,044	ELEVATION TOP OF BORING: 17.5 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX FOR SAMPLE NO.	ROD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			4. Borehole Reamed To 7.5" To Base of Rock. USGS Performed Borehole Logging. 5. 2" Monitoring Well Set @ X = 823754 Y= 522036 Screen From -40.7 to -42.7 Ft. 6. Cored to 80 Ft. To Confirm Out of Rock 7. Boring sealed with available sediment.						

115
120
125
130
135

SAJ FORM 1836-A
JUN 92


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0002
DEPTH: 173.200
S. Run #1


L-30 SEEPAGE MGMT PILOT PJT
CP06-L30P-CB-0002
DEPTH: 20.0-25.0'
S. RUN #2


L-30 SEEPAGE MGMT PILOT PGT
CPG6-L30PP-CB-0002
DEPTH: 250-300'
S. Run #3


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0002
DEPTH: 30.0-35.0'
S- Run # 4

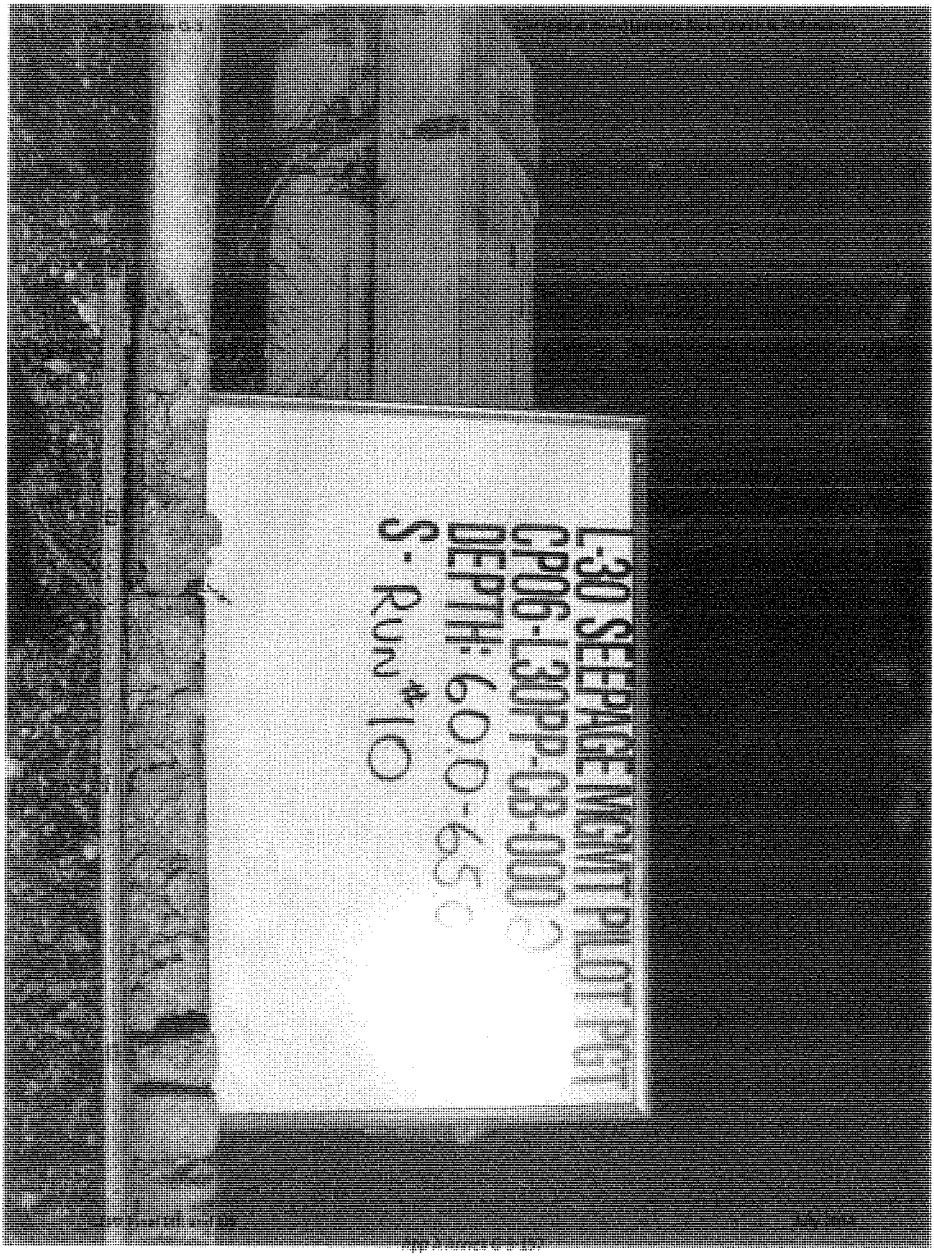
L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0002
DEPTH: 350-400
S. Run #5

L-30 SEEPAGE MGMT PILOT PGT
CP06-L30P-CB-0003
DEPTH: 40.0-45.0'
S. Reed '96

L-30 SEEPAGE MGMT PILOT PGT
GP06-L30PP-GB-0003
DEPTH: 450-500'
S. RUN #7

L-30 SEEPAGE MGMT PILOT PROJ
GROG-L30PP-CR-0002
DEPTH: 500-550'
S. Run #8

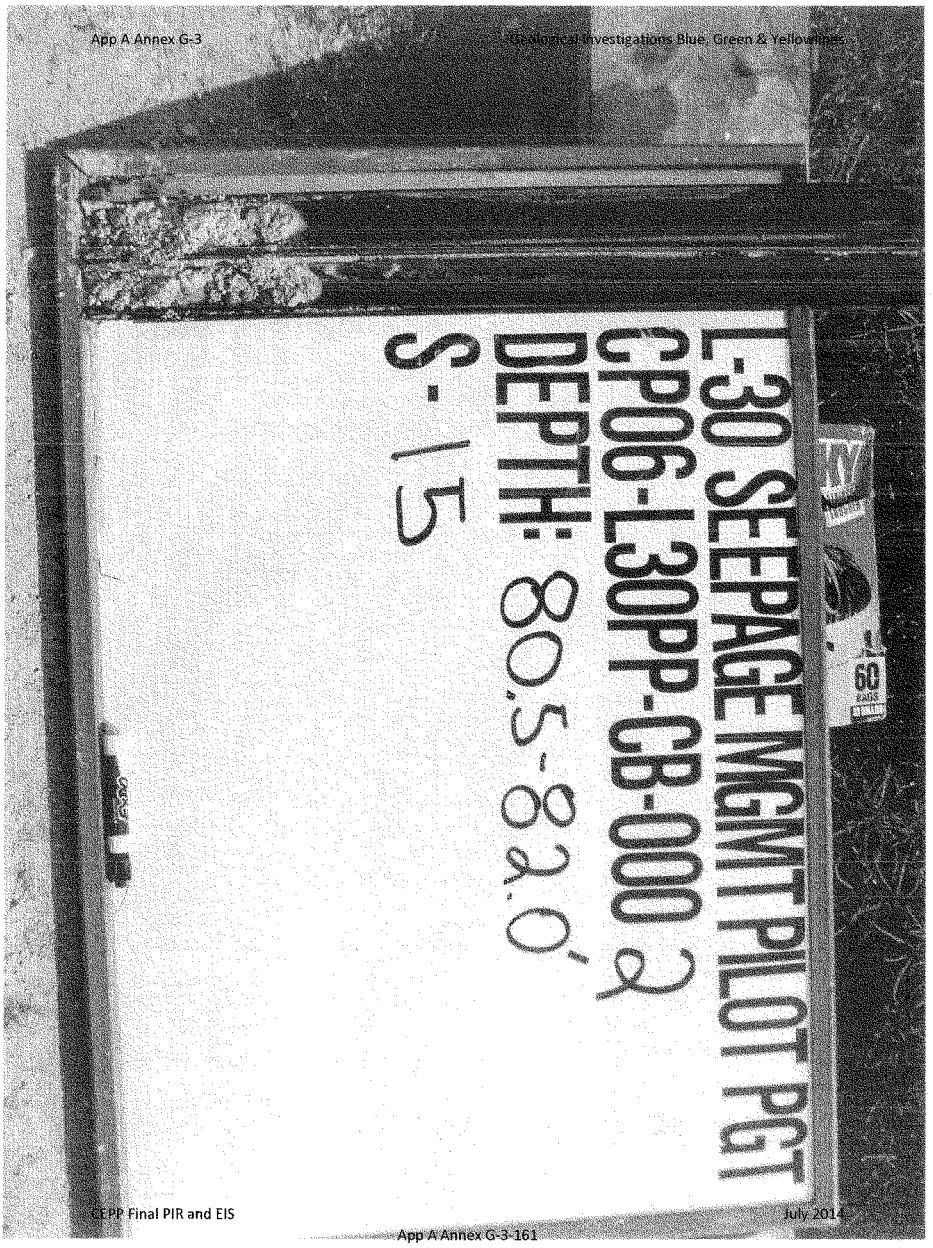
L30 SEEPAGE MGMT PILOT PGT
GP06-L30PP-GB-0002
DEPTH: 550-600'
S. RUN #6


L-30 SEEPAGE MGMT PLOT PRE
CP06-L30P-060002
DEPTH: 60.0-62.0
S. Run #10

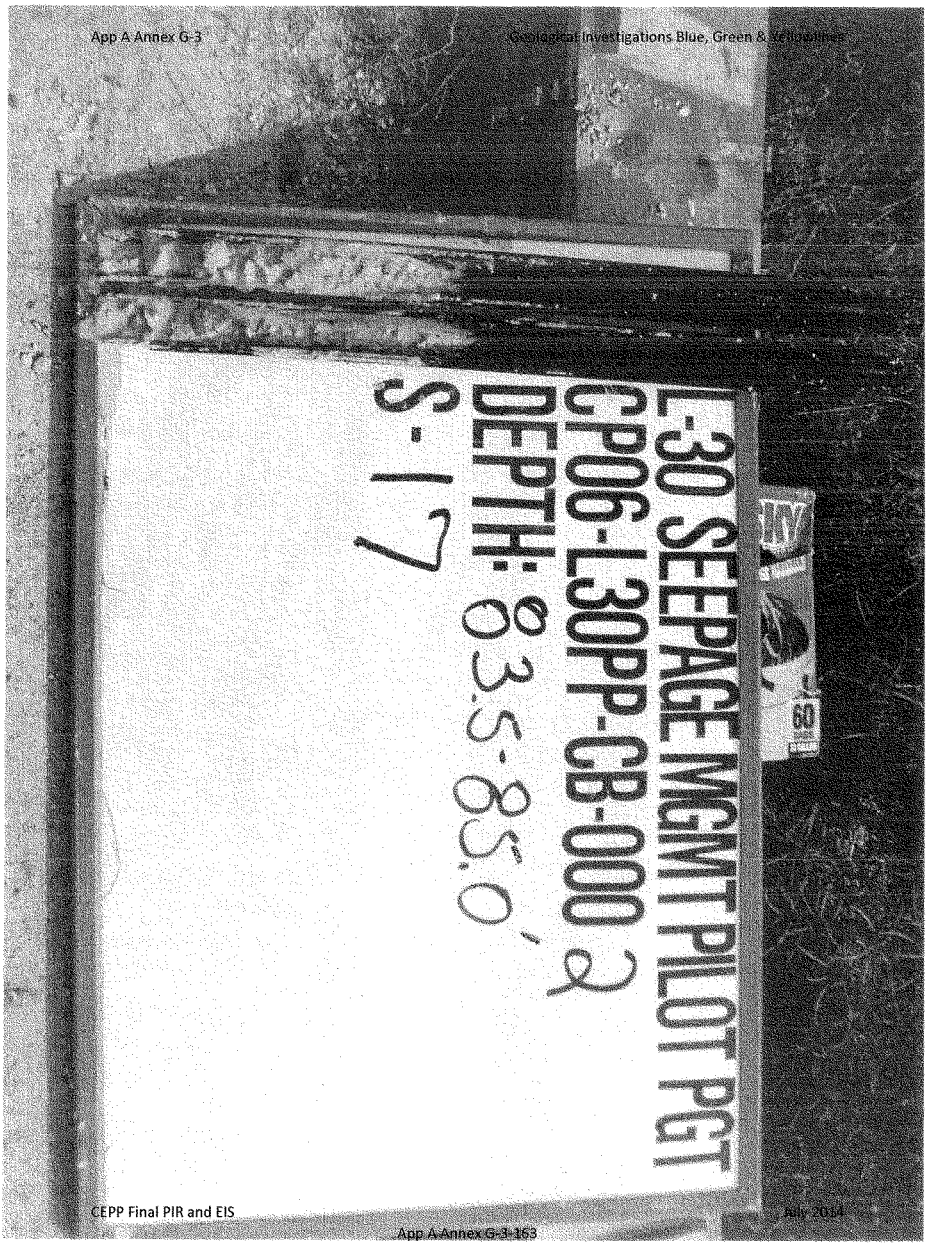
L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 65-70'
S. Run # 11

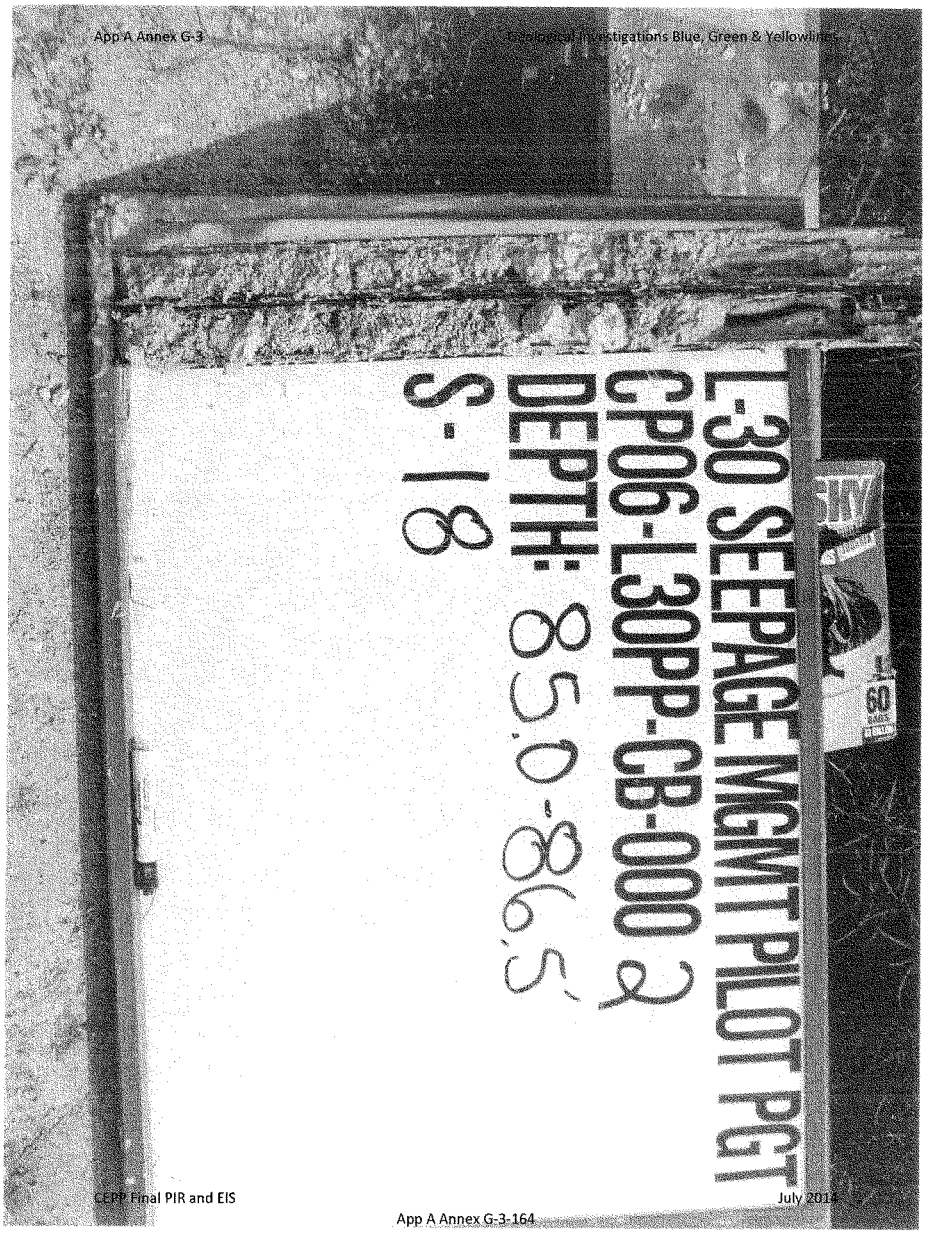
L30 SEEPAGE MGMT PLOT PGT
GP06-L30PP-CB-0003
DEPTH: 7000-7250
S# RUN #12

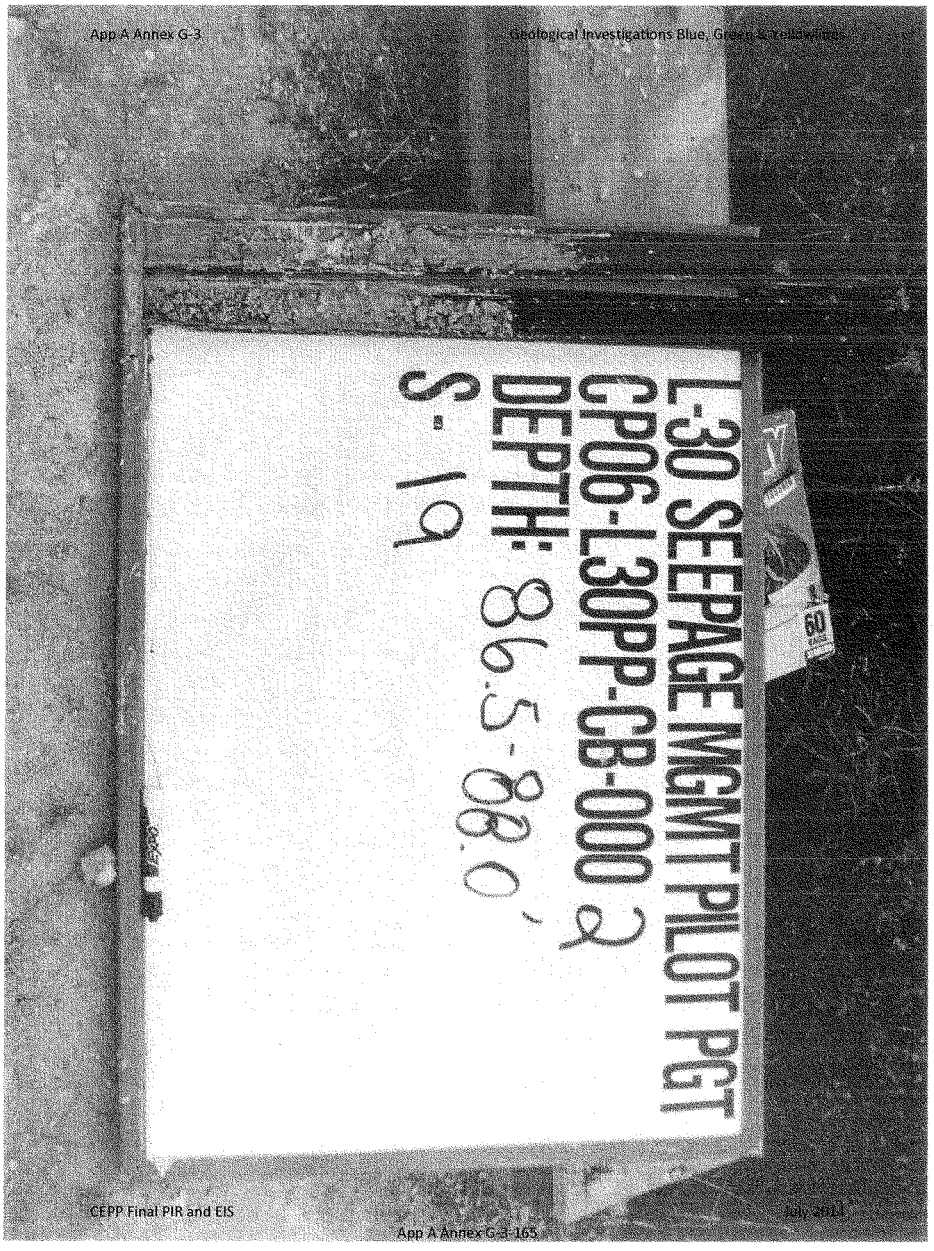

App A Annex G-3
Geological Investigations Blue, Green & Yellowlines
L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0002
DEPTH: 79.0-80.5'
S-14
60
CEPP Final PIR and EIS
App A Annex G-3-160
May 2014

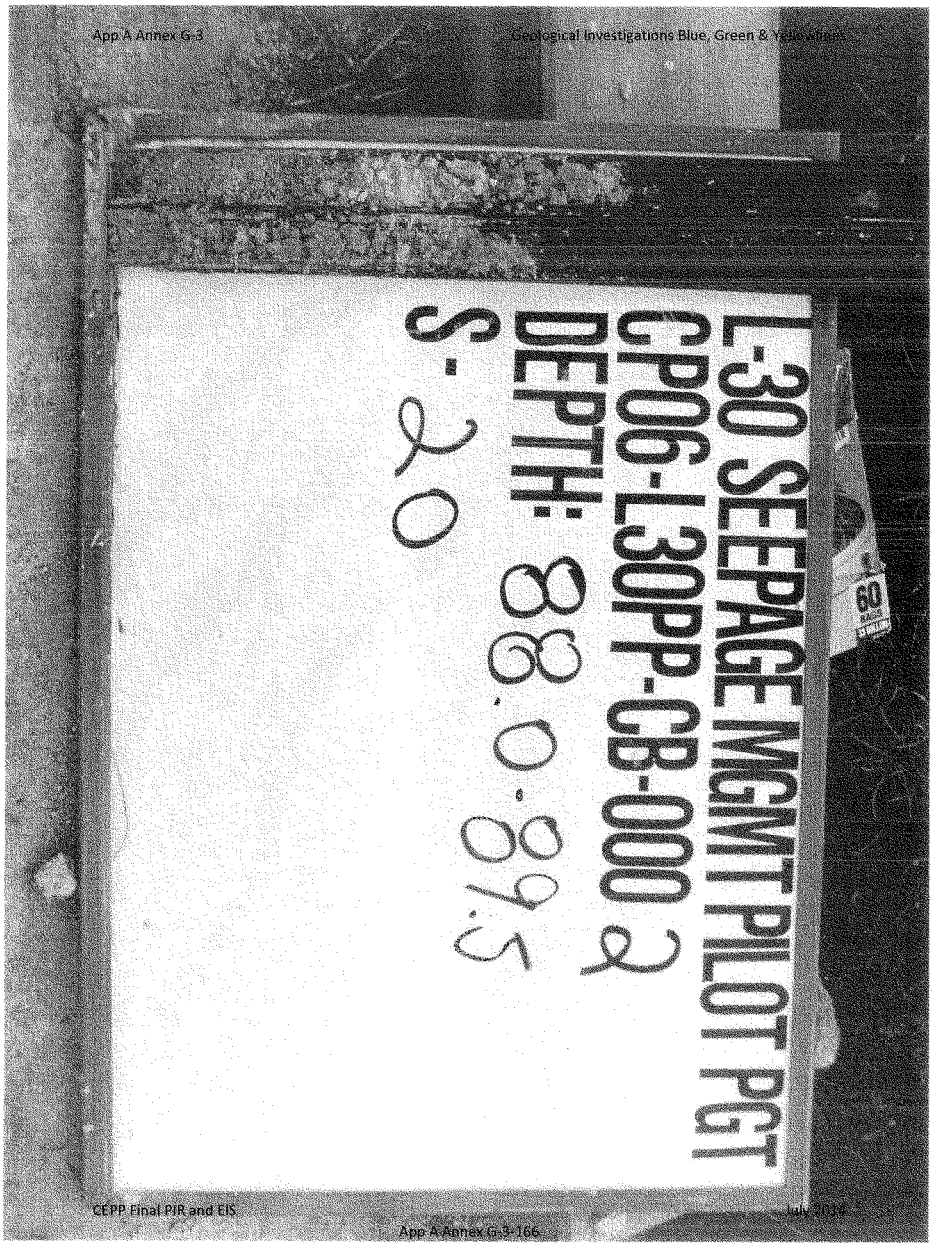

L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0002
DEPTH: 80.5-82.0'
S. 1-5


App A Annex G-3
Geological Investigations Blue, Green & Yellowlines
L-30 SEEPAGE MGMT PILOT PGT
GP06-L30PP-CB-0002
DEPTH: 82.0-83.5'
S- 16
CEPP Final PIR and EIS
July 2024
App A Annex G-3-162


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0002
DEPTH: 83.5-85.0'
S-17


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0002
DEPTH: 85.0-86.5'
S-18

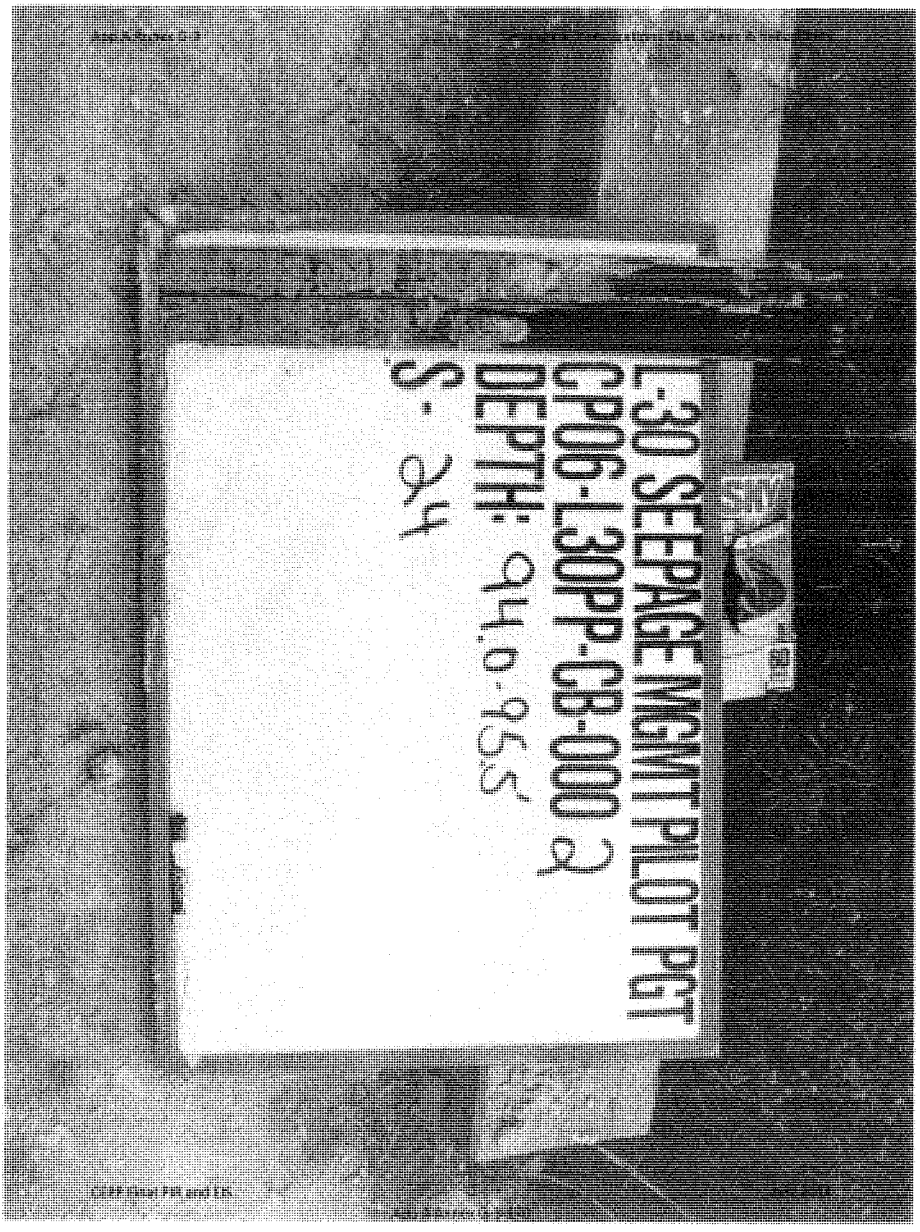

L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0002
DEPTH: 86.5-88.0'
S-19


L-30 SEEPAGE MGMT PILOT PGT
GP06-L30PP-CB-0002
DEPTH: 88.0'
S-20

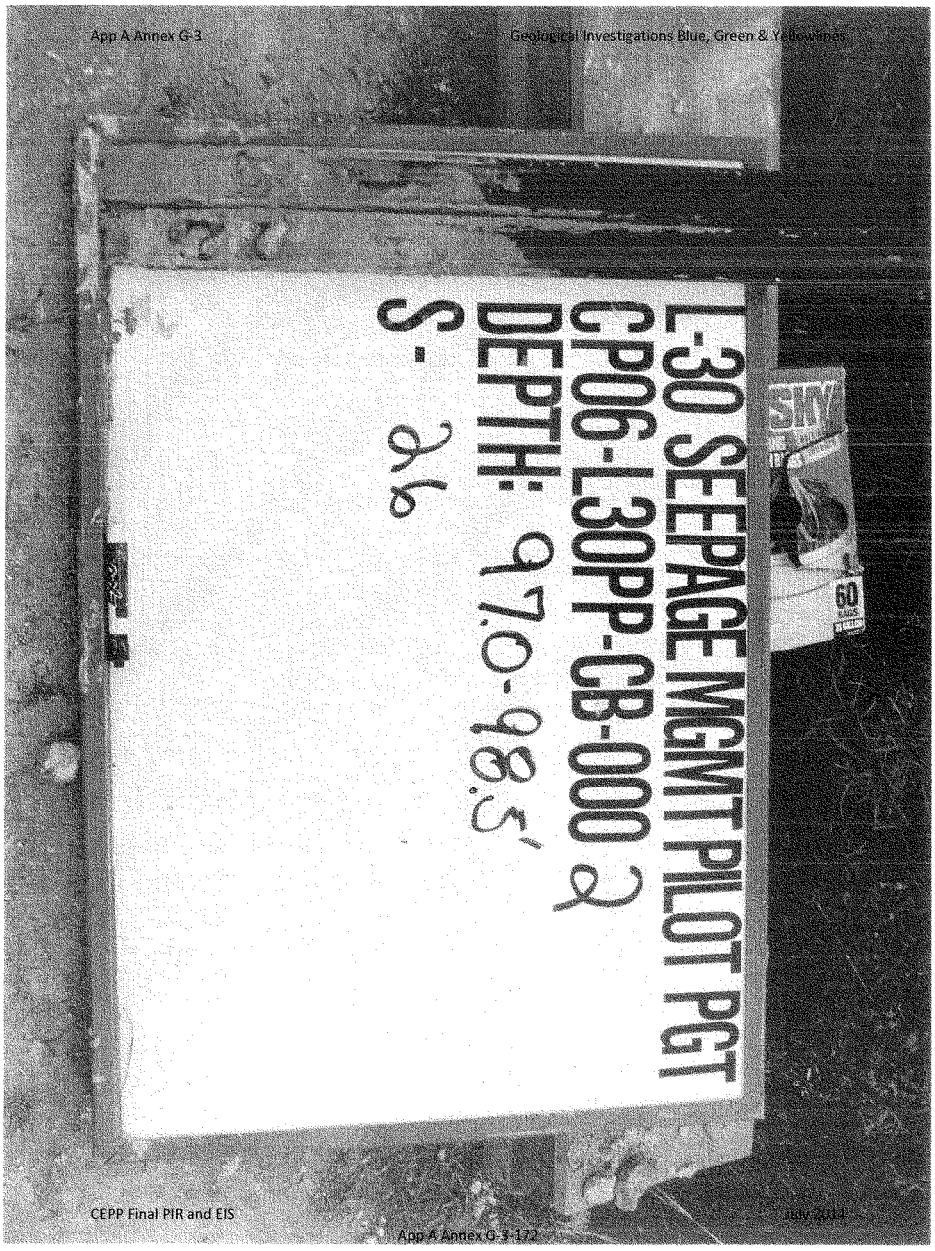
L-30 SEEPAGE MGMT PILOT PGT
SPOIL-L30PP-CB-0003
DEPTH: 8 to 9 ft
S.A.

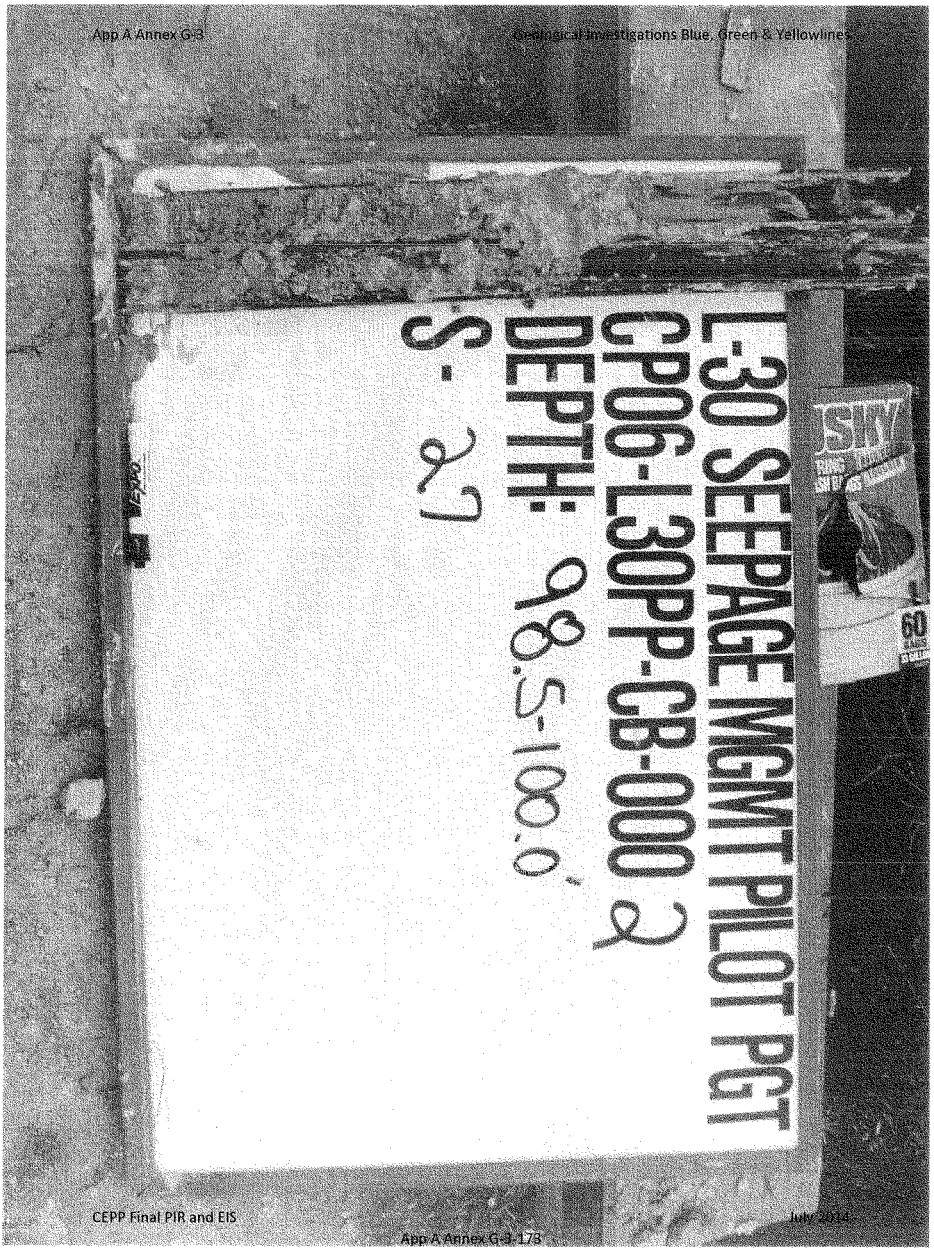

L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0002
DEPTH: 9.0-9.5'
S-24

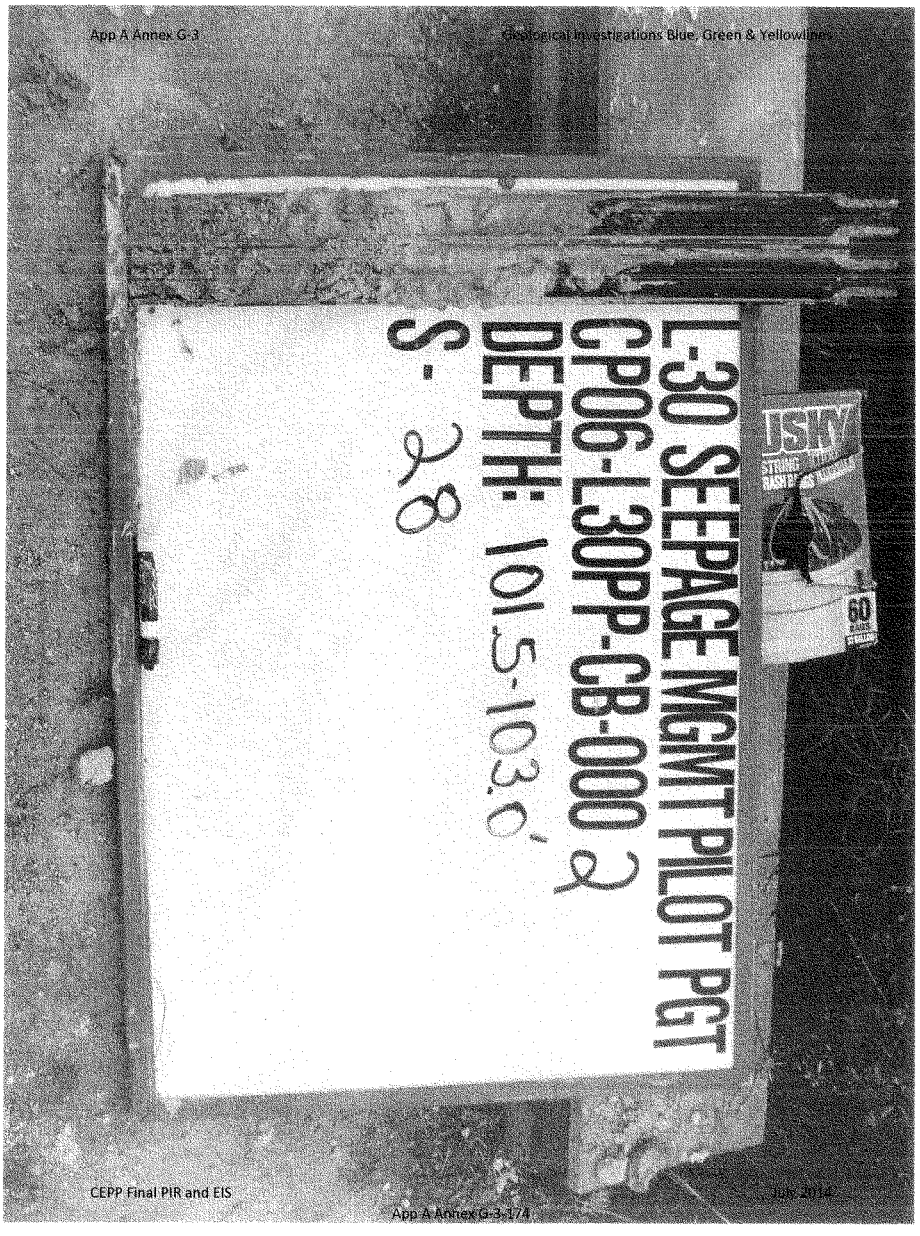

App A Annex G-3
Geological Investigations Blue, Green & Yellow Lines
L-30 SEEPAGE MGMT PILOT PGT
GP06-L30PP-CB-0002
DEPTH: 93.5-94.0'
S-23
CEPP Final PIR and EIS
App A Annex G-3-169
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L-30 SEEPAGE MGMT PILOT PGT
GP06-L30PP-CB-0003
DEPTH: 64.0-85.0
S: 94

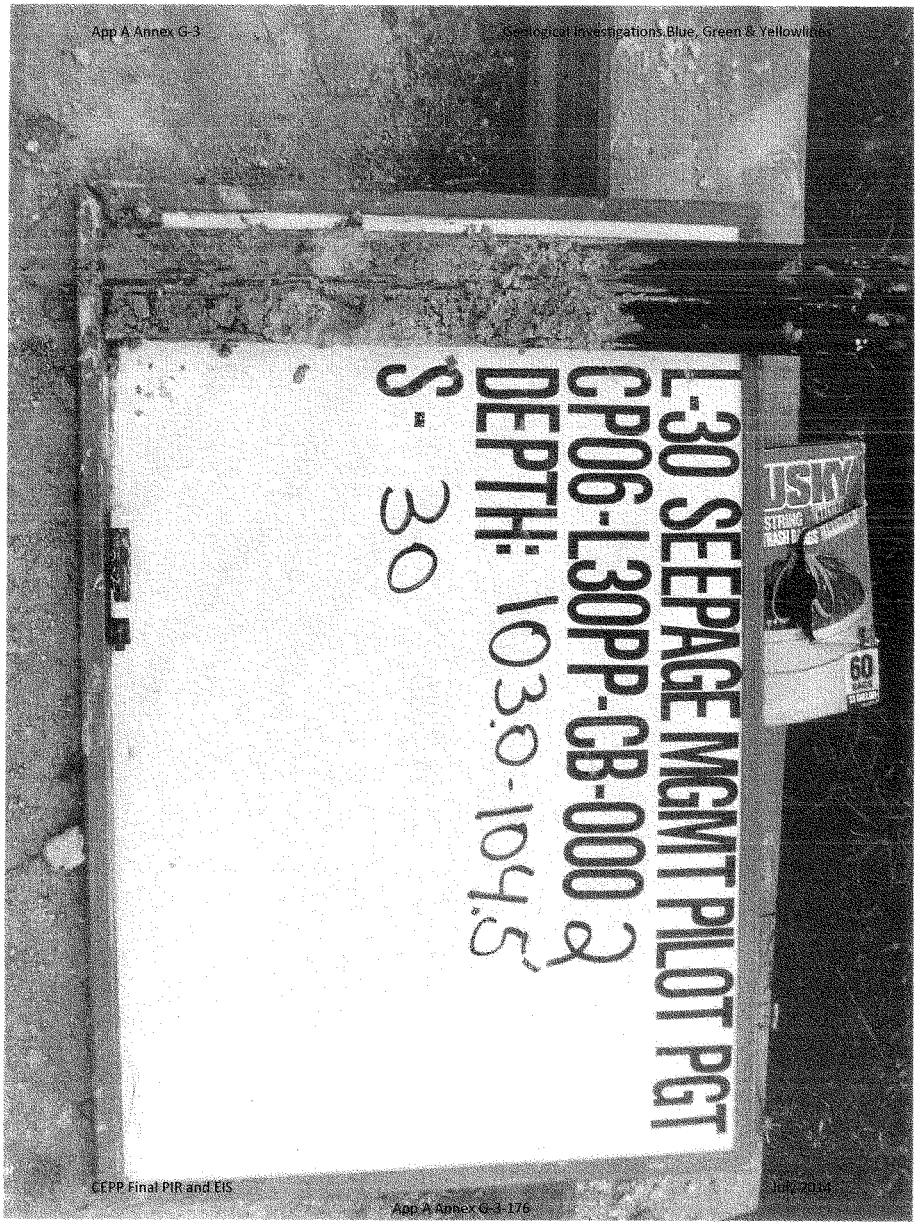

L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-000 2
DEPTH: 95.5-97.0
S: 25

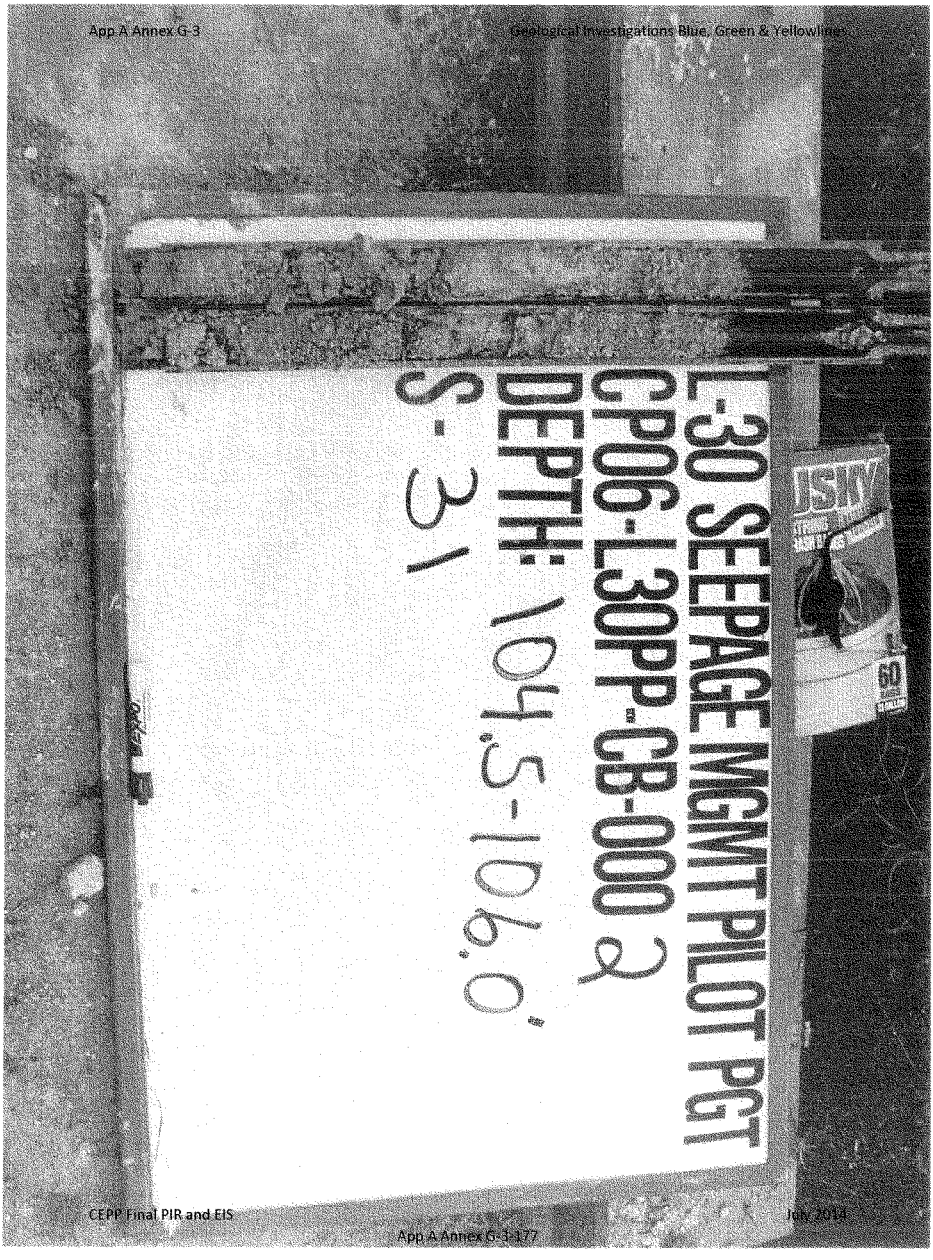

L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0002
DEPTH: 970-985'
S-26

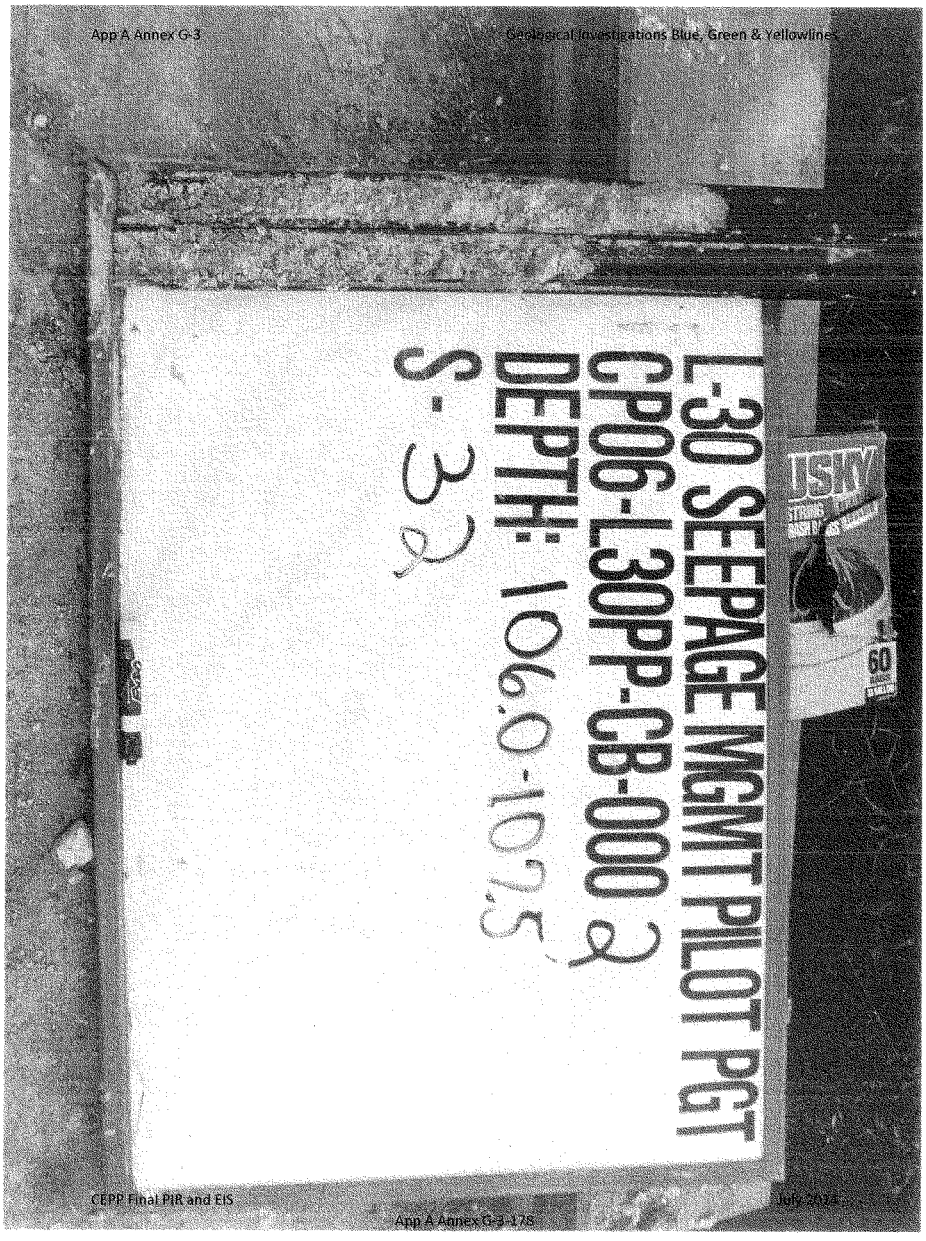

L-30 SEEPAGE MGMT PILOT PGT
GP06-L30PP-CB-0002
DEPTH: 98.5-100.0'
S.G.

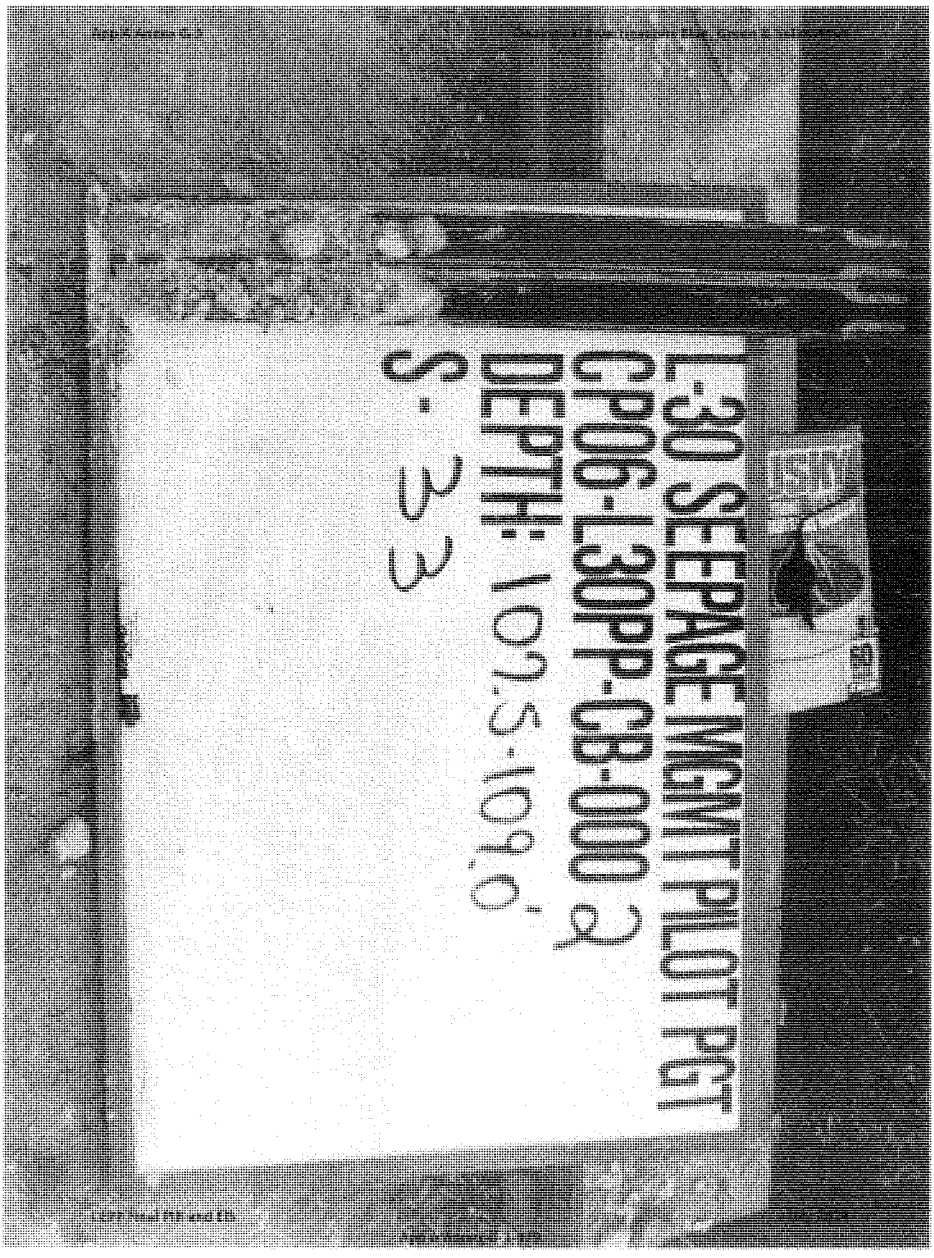

L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0002
DEPTH: 101.5-103.0'
S. 28

E30 SEEPAGE MGMT PILOT PGT
CP06-E30PP-CB-0003
DEPTH: 10'-15'
S-28


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0002
DEPTH: 1030-1045
S. 30
USKY


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0002
DEPTH: 1045-1060'
S-31


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0002
DEPTH: 1060-1075
S.32


L30 SEEPAGE MGMT PILOT PGT
GP06-L30PP-CB-0002
DEPTH: 10.5'-10.9'
S: 3 3

SOILS TEST CORE BORING NUMBER "CP06-L30PP-CB-0003"

Miami-Dade County, Florida

Boring Designation CP06-L30PP-CB-0003

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 6 SHEETS
1. PROJECT: L-30 Seepage Management Pilot Project Top Of Levee L-30 (Center of Roadway)		9. SIZE AND TYPE OF BIT: See Remarks 10. COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
2. BORING DESIGNATION: CP06-L30PP-CB-0003 / LOCATION COORDINATES: X = 821,358 Y = 519,743		11. MANUFACTURER'S DESIGNATION OF DRILL: CME 55 Truckrig ☐ AUTO HAMMER ☒ MANUAL HAMMER	
3. DRILLING AGENCY: Challenge Engineering & Testing, Inc. / CONTRACTOR FILE NO.: 2006D30		12. TOTAL SAMPLES: DISTURBED 33 / UNDISTURBED (UD) 0	
4. NAME OF DRILLER: Adam Benson		13. TOTAL NUMBER CORE BOXES: 5	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED / DEG. FROM VERTICAL / BEARING		14. ELEVATION GROUND WATER: 5.0 Ft.	
		15. DATE BORING: STARTED 10-07-06 / COMPLETED 10-18-06	
6. THICKNESS OF OVERBURDEN: N/A		16. ELEVATION TOP OF BORING: 17.2 Ft.	
7. DEPTH DRILLED INTO ROCK: N/A		17. TOTAL RECOVERY FOR BORING: 73 %	
8. TOTAL DEPTH OF BORING: 105.0 Ft.		18. SIGNATURE AND TITLE OF INSPECTOR: Bob Momberger, Geologist	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD OR CORE NO.	REMARKS	BLOWS/0.5 FT. N-VALUE
17.2	0.0						17.2	
			L-30 Levee Fill Material				Advanced Boring w/ tricone roller bit	

0 5 10 15

SAJ FORM 1836
JUN 02

(Continued)

Boring Designation CP06-L30PP-CB-0003

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 2 OF 6 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 821,358 Y = 519,743	ELEVATION TOP OF BORING: 17.2 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR COREDS	REMARKS	BLOWS/0.5 FT. N-VALUE
-0.3	17.5						Advanced Boring w/ tricone roller bit	
			LIMESTONE, oolitic, sparsely fossiliferous, moderately hard, slightly weathered, fine-grained, thick bedding, vuggy, peat filled vugs, Ft. Thompson Formation, 2.5Y 8/2 pale yellow	100	1	RQD 50	4 x 5-1/2" Diamond Impregnated Bit DT = 3 mins HP = 250 psi DFR = 50 %	
			At El. -2.8 Ft., vuggy, quartz filled vugs				-2.8	
			From El. -4.3 to -12.8 Ft., aphanitic, thick bedding, pitted, sand filled pits, 2.5Y 7/2 light gray	100	2 BOX 1	RQD 30	4 x 5-1/2" Diamond Impregnated Bit DT = 6 mins HP = 250 psi DFR = 25 %	
			At El. -6.8 Ft., pitted, clay filled pits				-7.6	
				70	3	RQD 45	4 x 5-1/2" Diamond Impregnated Bit DT = 5 mins HP = 250 psi DFR = 0 %	
-12.8	30.0						-12.8	
			LIMESTONE, fossiliferous, very soft, slightly weathered, aphanitic, thin bedding, vuggy, clay filled vugs, 2.5Y 8/1 white	6	BOX 2 4	RQD 0	4 x 5-1/2" Diamond Impregnated Bit DT = 3 mins HP = 250 psi DFR = 0 %	
							-17.8	

Slightly Weathered

SAJ FORM 1836-A
JUN 02

Boring Designation CP06-L30PP-CB-0003

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 3 OF 6 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 821,358 Y = 519,743	ELEVATION TOP OF BORING: 17.2 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	RQD OR COR	REMARKS	BLOWS/0.5 FT.	N-VALUE
			At El. -17.8 Ft., sparsely fossiliferous, moderately hard, slightly weathered, aphanitic, thick bedding, pitted	90	5	RQD 50	4 x 5-1/2" Diamond Impregnated Bit DT = 4 mins HP = 250 psi DFR = 0 %		
			At El. -21.8 Ft., fossiliferous				-22.8		
			At El. -25.8 Ft., soft, vuggy, clay filled vugs	96	BOX 2 6	RQD 20	4 x 5-1/2" Diamond Impregnated Bit DT = 2 mins HP = 250 psi DFR = 0 %		
			At El. -27.3 Ft., moderately hard, unweathered, aphanitic, medium bedding, vuggy, sand filled vugs, 5Y 8/1 white				-27.8		
				70	7	RQD 20	4 x 5-1/2" Diamond Impregnated Bit DT = 3 mins HP = 250 psi DFR = 0 %		
							-32.8		
				90	BOX 3 8	RQD 25	4 x 5-1/2" Diamond Impregnated Bit DT = 4 mins HP = 250 psi DFR = 0 %		
							-37.8		

SAJ FORM 1836-A
JUN 02

Boring Designation CP06-L30PP-CB-0003

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 4 OF 6 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.)	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 821,358 Y = 519,743	ELEVATION TOP OF BORING: 17.2 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	RQD OR COR.	REMARKS	BLOWS/0.5 FT.	N-VALUE
		Slightly Weathered	At El. -37.8 Ft., slightly weathered, pitted, 2.5Y 8/1 white	70	9 BOX 3	RQD 20	4 x 5-1/2" Diamond Impregnated Bit DT = 2 mins HP = 250 psi DFR = 0 %		
-44.8	62.0	Unweathered	LIMESTONE, hard, unweathered, pitted, 2.5Y 6/1 gray	80	10	RQD 20	4 x 5-1/2" Diamond Impregnated Bit DT = 7 mins HP = 250 psi DFR = 0 %		
			At El. -47.8 Ft., moderately weathered, thin bedding, vuggy, clay filled vugs						
-49.8	67.0	Moderately Weathered	LIMESTONE, soft, clay filled vugs	40	11 BOX 4	RQD 0	4 x 5-1/2" Diamond Impregnated Bit DT = 2 mins HP = 250 psi DFR = 0 %		
-54.8	72.0		SHELL, mostly angular sand to gravel-sized shell up to 1/2", few fine-grained sand-sized carbonate, trace limestone up to 1/8", strong reaction with HCl, wet, 5Y 7/1 light gray	20	12	RQD 0	4 x 5-1/2" Diamond Impregnated Bit DT = 1 mins HP = 250 psi DFR = 0 %		
			At El. -57.1 Ft., little fine-grained sand-sized carbonate, Pinecrest Sand Formation						

-42.8 -47.8 -52.8 -57.8

55 60 65 70 75

SAJ FORM 1836-A
JUN 02

Boring Designation CP06-L30PP-CB-0003

DRILLING LOG (Cont. Sheet)	INSTALLATION Jacksonville District		SHEET 5 OF 6 SHEETS
PROJECT L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM State Plane, FLE (U.S. Ft.)	HORIZONTAL NAD83	VERTICAL NAVD88
LOCATION COORDINATES X = 821,358 Y = 519,743	ELEVATION TOP OF BORING 17.2 Ft.		

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE NO.	ROD OR CORE SIZE	REMARKS	BLOWS/0.5 FT.	N-VALUE
				0	13	NQ	4 X 6-1/2" Diamond Impregnated Bit		
						0			
				67	14		SPT Sampler	2	4
							-59.3	2	
				73	15		SPT Sampler	3	6
							-60.8	2	
								4	
				73	16		SPT Sampler	3	5
							-62.3	2	
			At El. -62.3 Ft., mostly angular fine to coarse gravel-sized shell up to 1/2", few silt, few clay, strong reaction with HCl, wet, 10Y 6/1 greenish gray					3	
				47	17		SPT Sampler	7	12
							-63.8	6	
								6	
				97	18		SPT Sampler	5	11
-65.3	82.5						-65.3	4	
								7	
			SAND, silty, mostly fine-grained sand-sized carbonate, little angular sand to gravel-sized shell up to 1/2", few sandstone, strong reaction with HCl, wet, moderate cementation, N 6/ gray (SM)	100	19		-65.6 SPT Sampler	50/0.3'	
-66.8	84.0						Advanced Boring -66.8		
			SHELL, low plasticity, mostly angular sand to gravel-sized shell up to 1/2", little clay, few silt, strong reaction with HCl, wet, 10Y 6/1 greenish gray	90	20		SPT Sampler	14	31
							-68.3	14	
								17	
				53	21		SPT Sampler	9	40
							-69.8	19	
			At El. -69.8 Ft., mostly angular fine gravel-sized shell up to 3/4", few silt, strong reaction with HCl, wet, 10Y 6/1 greenish gray					21	
				80	22		SPT Sampler	19	48
							-71.3	22	
								26	
			At El. -71.3 Ft., little silt					22	
				90	23		SPT Sampler	21	38
-72.8	90.0						-72.8	17	
			SAND, silty, mostly medium-grained sand-sized quartz, some angular medium-grained sand-sized shell up to 1/4", strong reaction with HCl, wet, N 6/ gray (SM)	97	24		SPT Sampler	11	27
							-74.3	12	
								15	
				97	25		SPT Sampler	14	28
							-75.8	14	
								14	
				97	26		SPT Sampler	9	13
							-77.3	6	
								7	
				67	27		SPT Sampler	8	

SAJ FORM 1836-A
JUN 02

Boring Designation CP06-L30PP-CB-0003

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 6 OF 6 SHEETS
PROJECT: L-30 Seepage Management Pilot Project	COORDINATE SYSTEM/DATUM: State Plane, FLE (U.S. Ft.) / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 821,358 Y = 519,743	ELEVATION TOP OF BORING: 17.2 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	CORE OD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			At El. -77.8 Ft., some angular sand to gravel-sized shell up to 1/2", trace silt, strong reaction with HCl, wet, N 6/ gray	67	27		SPT Sampler	5 6	11
							-78.8		
			At El. -78.8 Ft., some angular sand to gravel-sized shell up to 1"	97	28		SPT Sampler	2 3 7	10
							-80.3		
				97	29		SPT Sampler	29 25 23	48
							-81.8		
			At El. -81.8 Ft., little angular medium-grained sand-sized shell up to 1/4", strong reaction with HCl, wet, N 6/ gray	97	30		SPT Sampler	12 20 27	47
							-83.3		
			At El. -83.3 Ft., some angular sand to gravel-sized shell up to 1"	93	31		SPT Sampler	10 26 28	54
							-84.8		
			At El. -84.8 Ft., some angular sand to gravel-sized shell up to 1-1/2"	70	32		SPT Sampler	15 26 13	39
							-86.3		
			At El. -86.3 Ft., little angular sand to gravel-sized shell up to 1/2", weak cementation, 10Y 7/1 light greenish gray	73	33		SPT Sampler	6 7 8	15
-87.8	105.0						-87.8		

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

2. Set 17.5 Ft. of 8" Schedule 40 PVC Pipe Through Center of L-30 Levee To Top of Rock.

3. Boring Drilled/Sampled In Three Phases:
A. Set Surface Casing.
B. 4" Wireline Rock Coring To Base Of Rock.
C. Splitspoon Sampling 30 Ft. Below Base of Rock.

4. Borehole Reamed To 7.5" To Base of Rock. USGS Performed Borehole Logging.

5. 2" Monitoring Well Set @
X = 821356 Y= 519734

Screen From -41.8 to -43.8 Ft.

6. Cored to 60 Ft. To Confirm Out of Rock

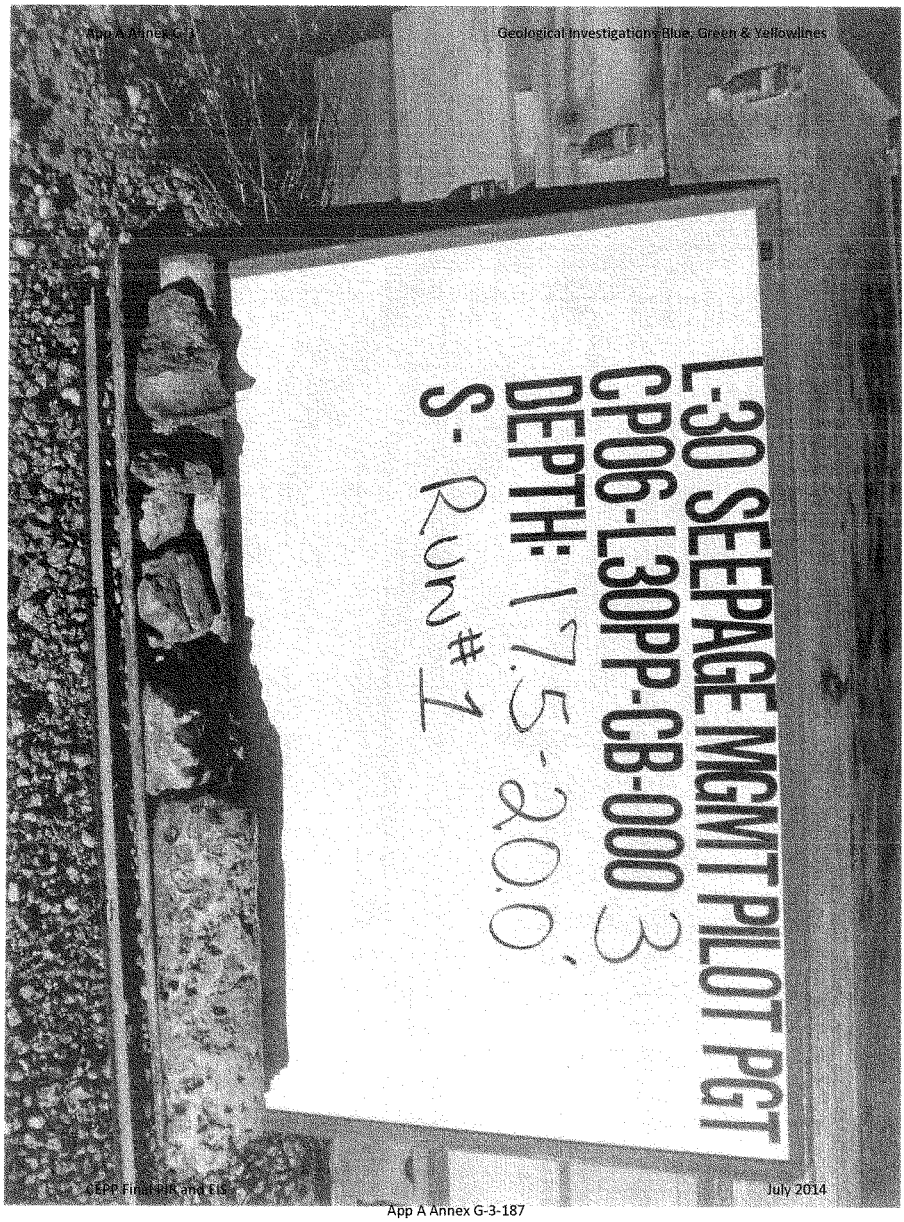
7. Boring sealed with available sediment.

140# hammer w/30" drop used with 2.0' split spoon (1-3/8" I.D. x 2" O.D.).

Abbreviations:
DT = Drill Time.
HP = Hydraulic Pressure.
DFR = Drill Fluid Return.

95 100 105 110 115

SAJ FORM 1836-A
JUN 02

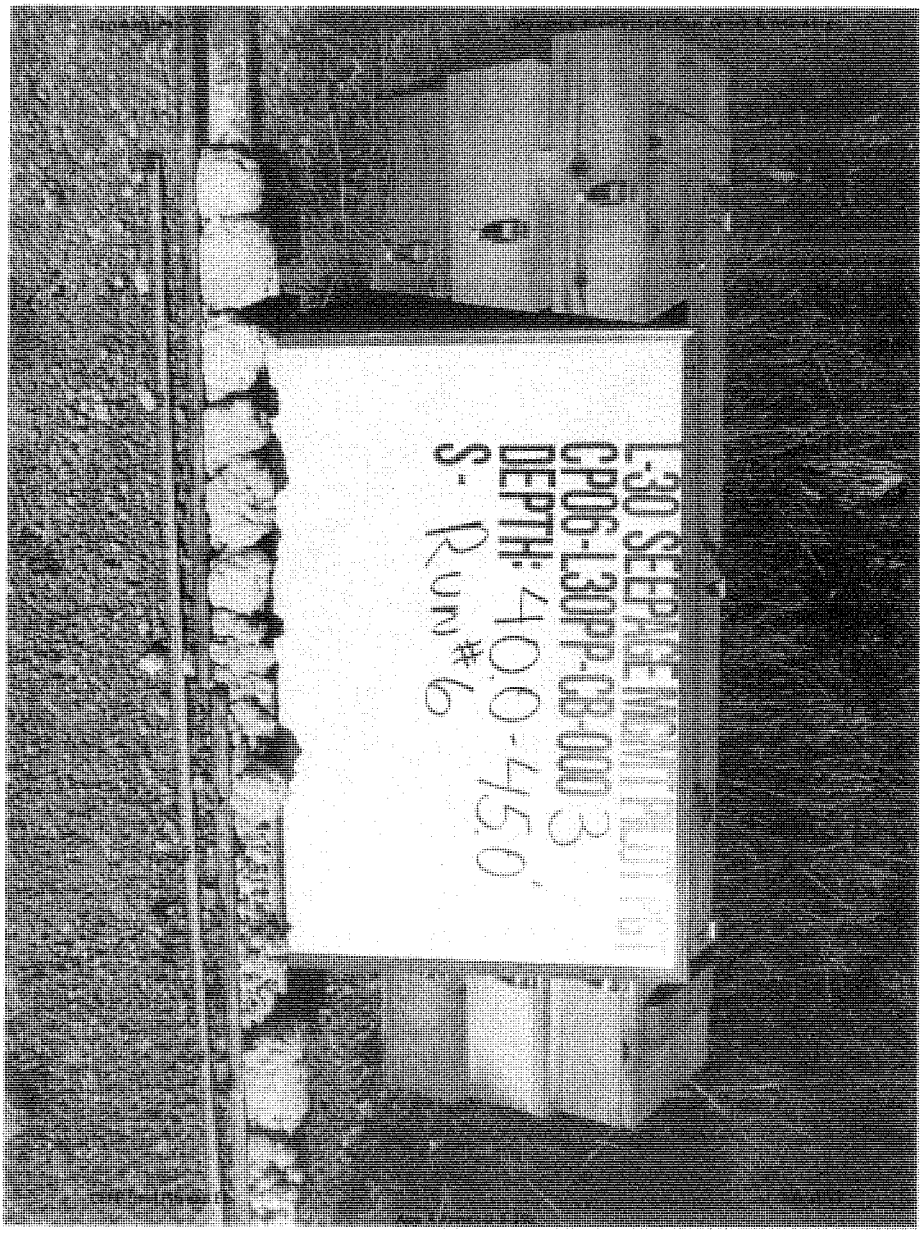

App A Annex G-3
Geological Investigations Blue, Green & Yellowlines
L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 175-200'
S. RUN#1

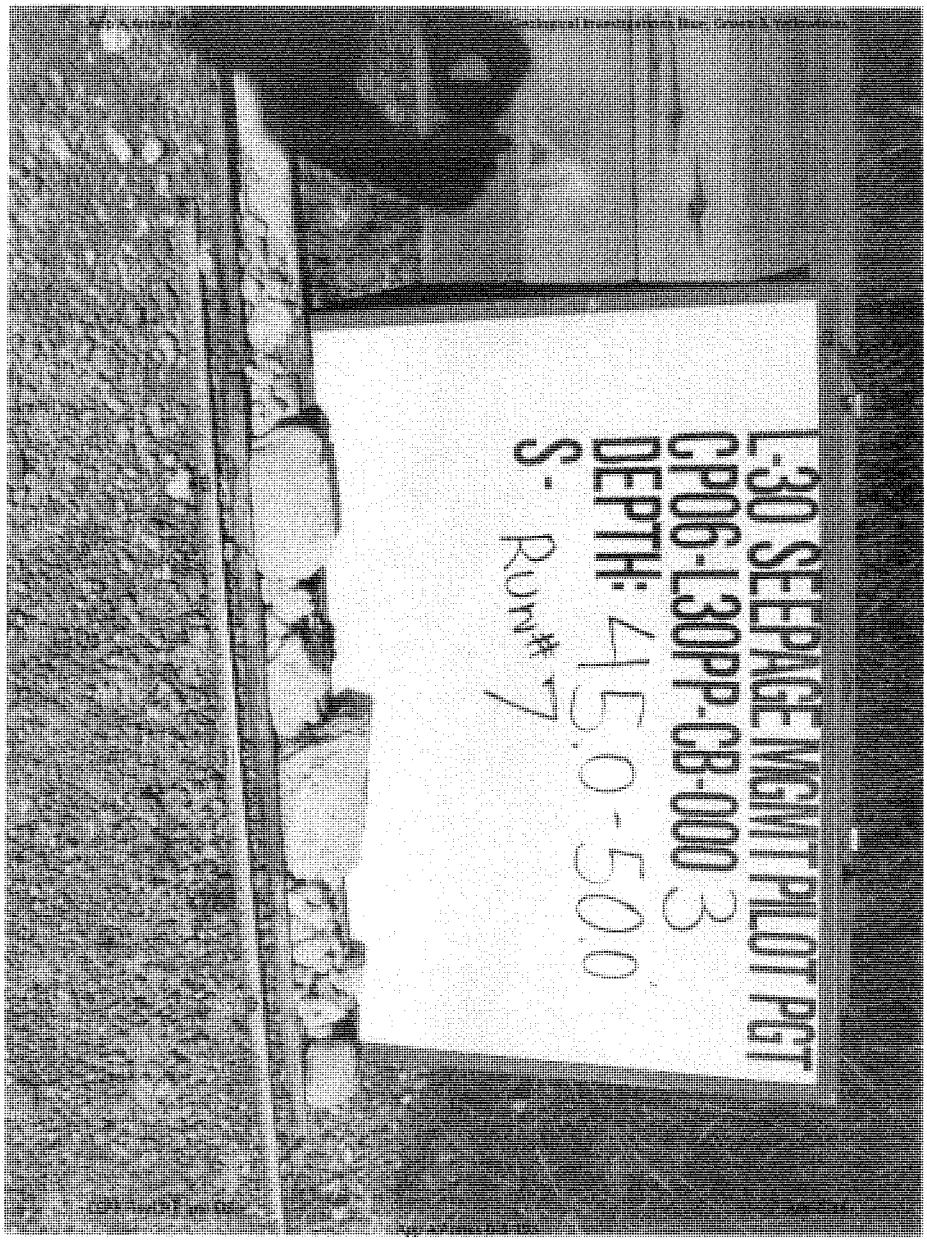
L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 200-250'
S. Run #2

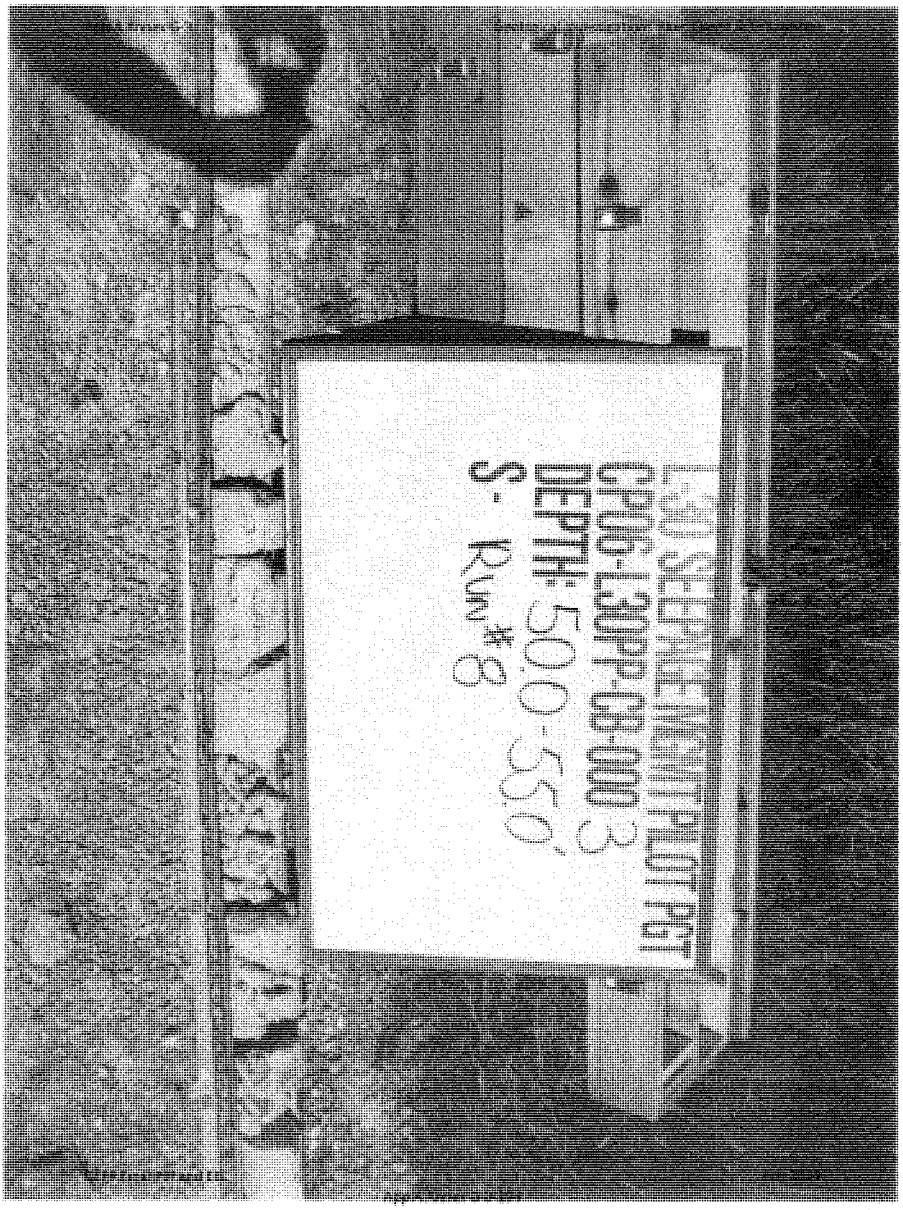
L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 270-300
S. 7622 #3


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 30.0-32.0
S- Run #1


L-30 SEEPAGE MGMT PILOT PGT
CPOG-L30PP-CB-0003
DEPTH: 35.0-40.0
S. Run #5


LEG SEDIMENTOLOGY LAB
CPOS-130PP-CB-003
DEPTH: 470-475 cm
S. Crum

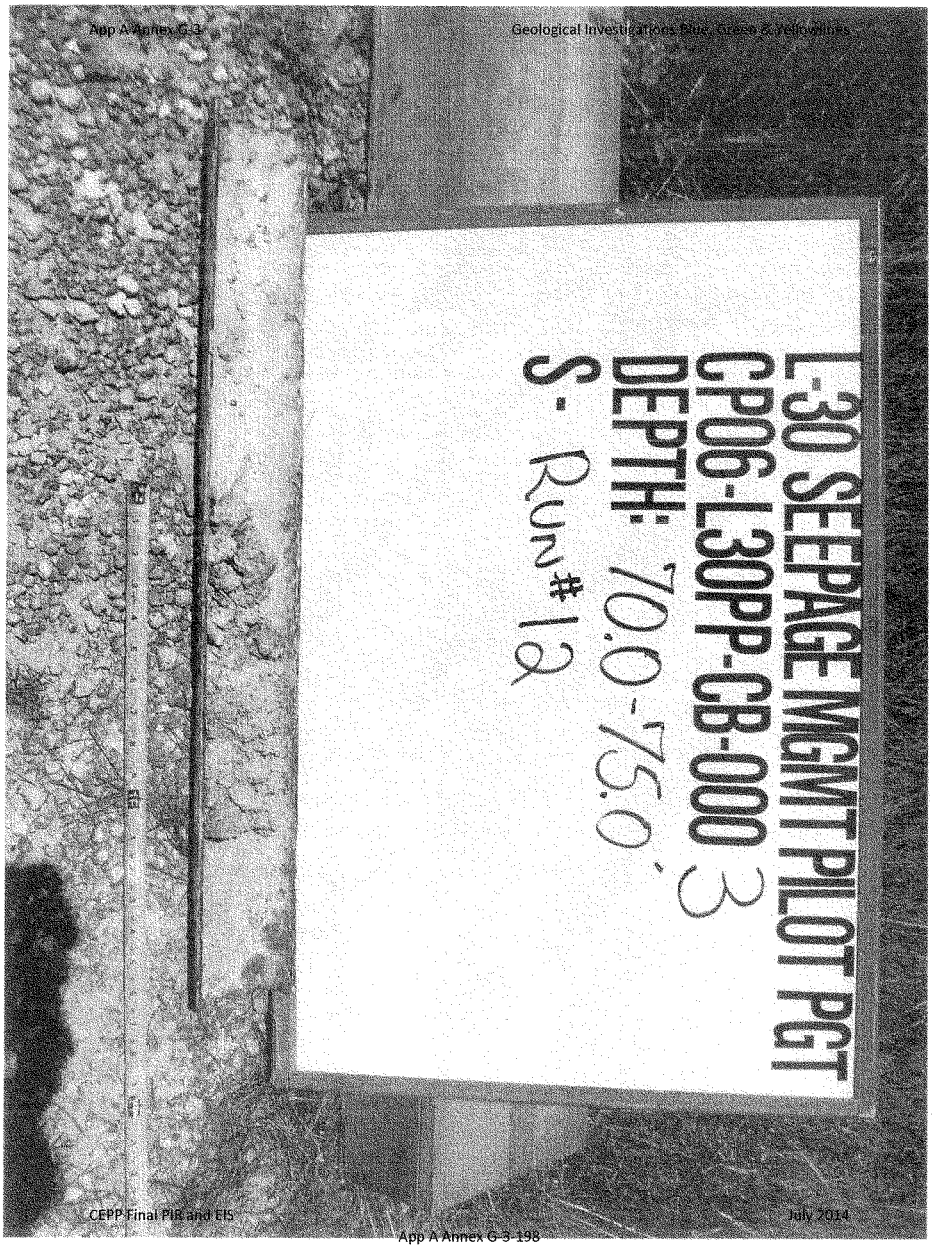

L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 415.0-500
S- Run# 7

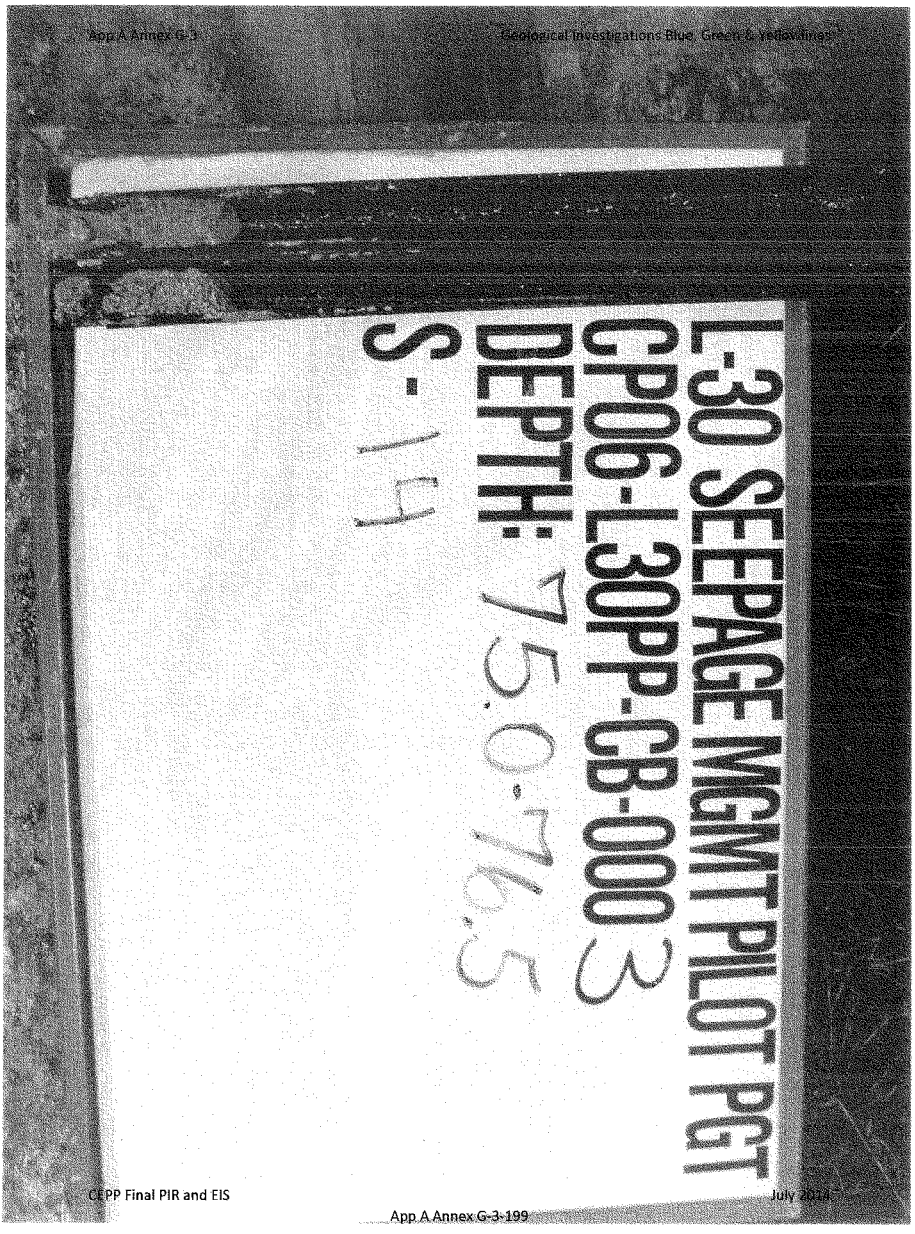

EQUIPMENT PLOT
PROFILE
DEPTH: 500-550'
S. KWM 8

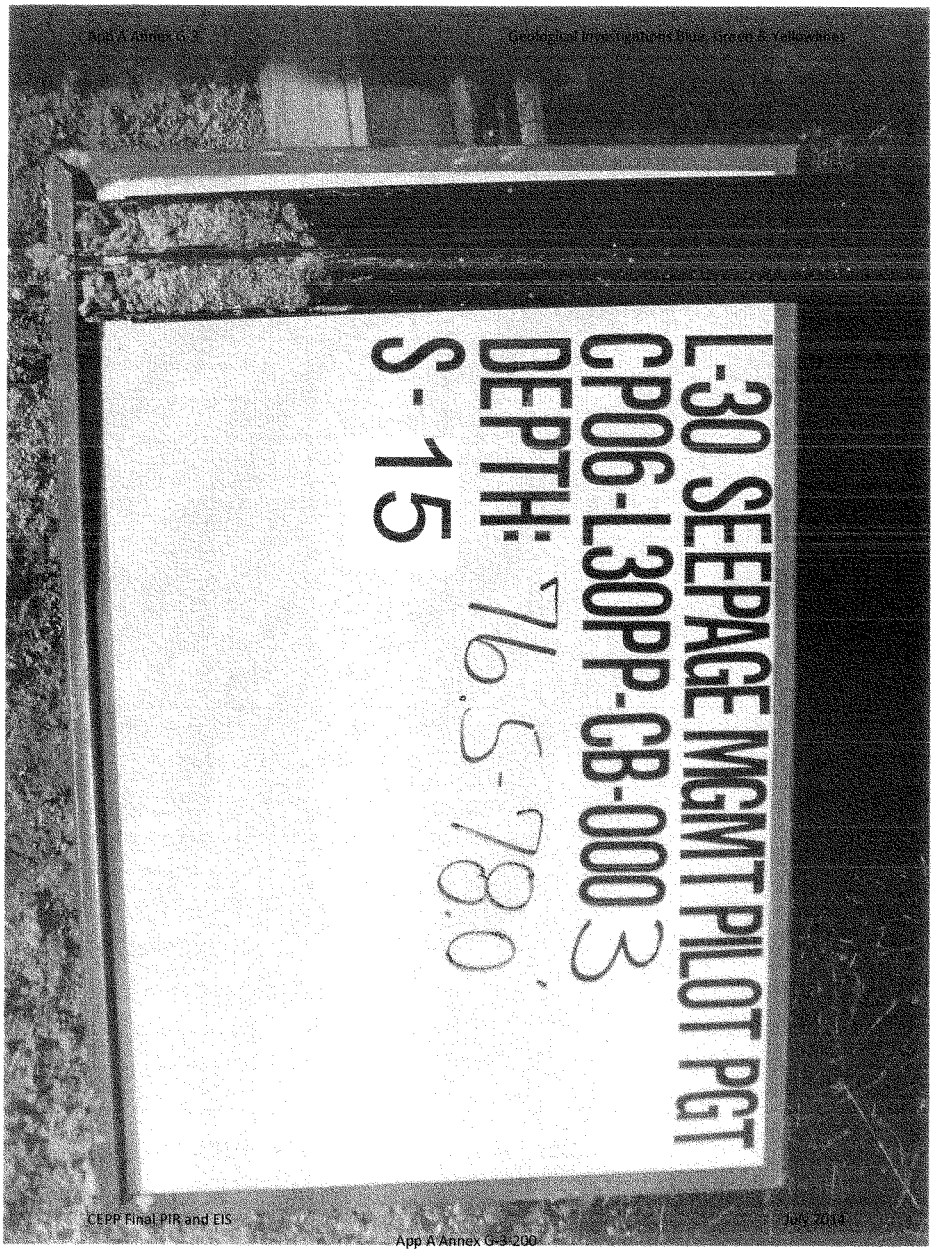
L-30 SEEPAGE MGMT PILOT PROJECT
CP06-L30P-CB-0003
DEPTH: 5'-0"
S. Run #5

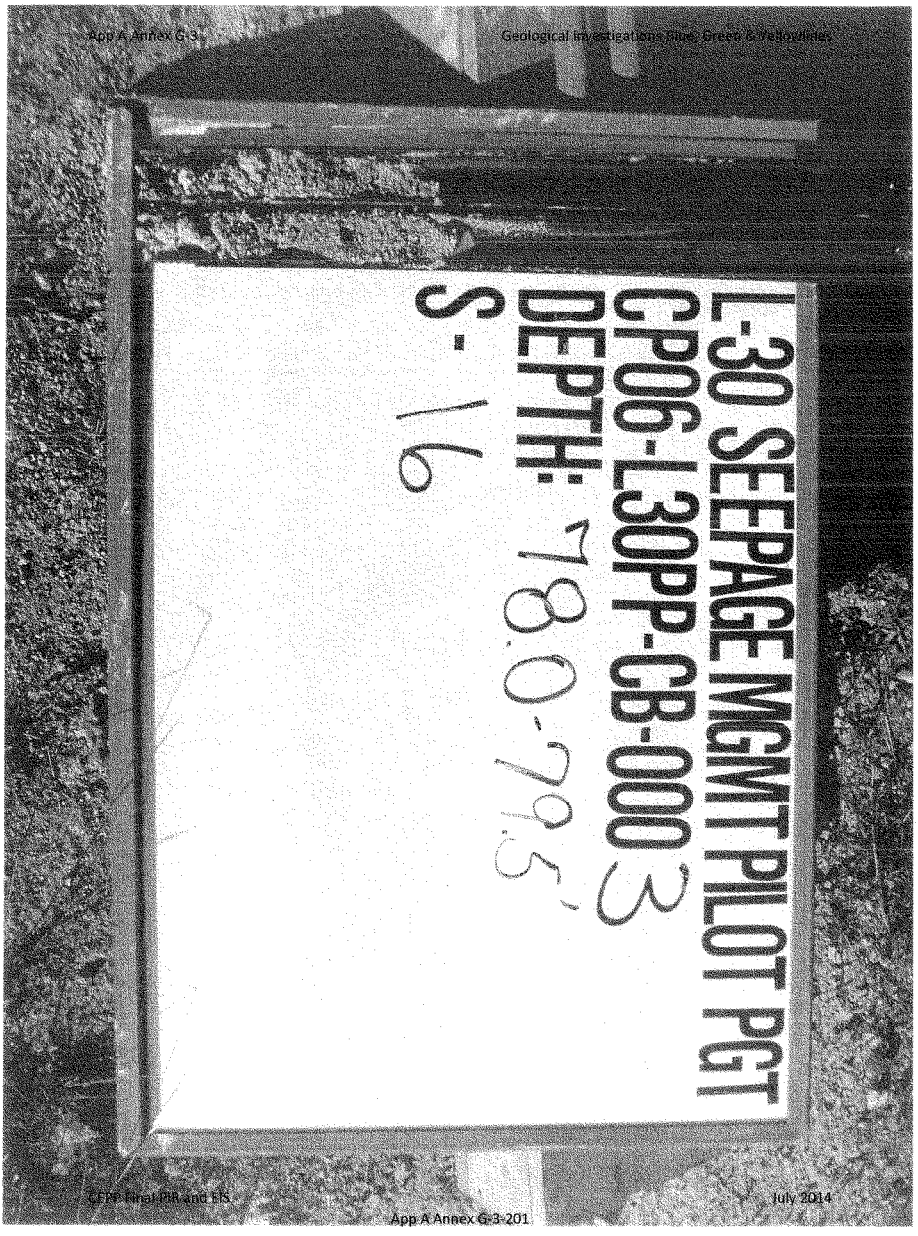
L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 600-650'
S. RUN #10

L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 650-700'
S. Run #1


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-000 3
DEPTH: 70.0-75.0'
S- Run#12

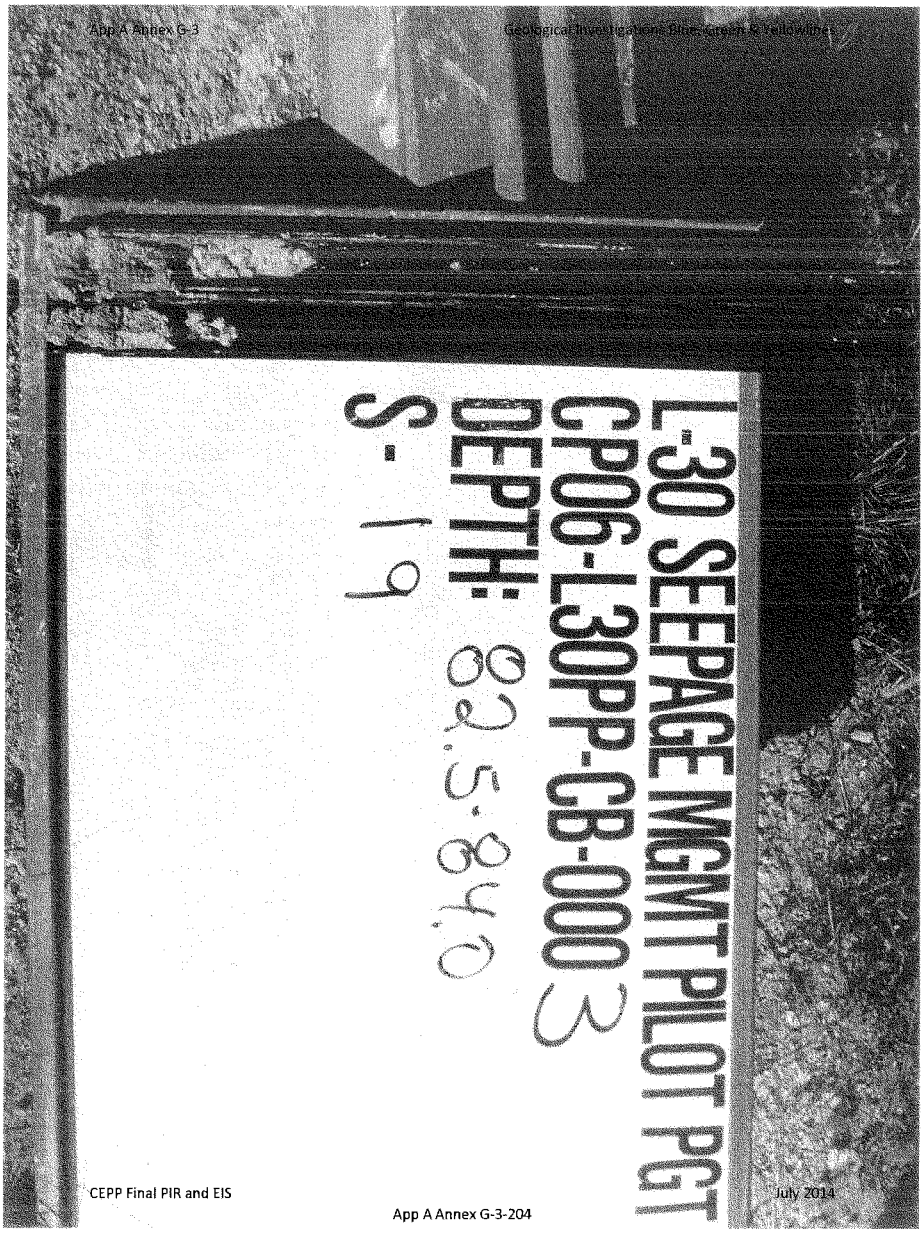

App A Annex G-3
Geological Investigations Blue, Green & yellow lines
L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 75.0-76.5
S-1
CEPP Final PIR and EIS
App A Annex G-3-199
July 2014

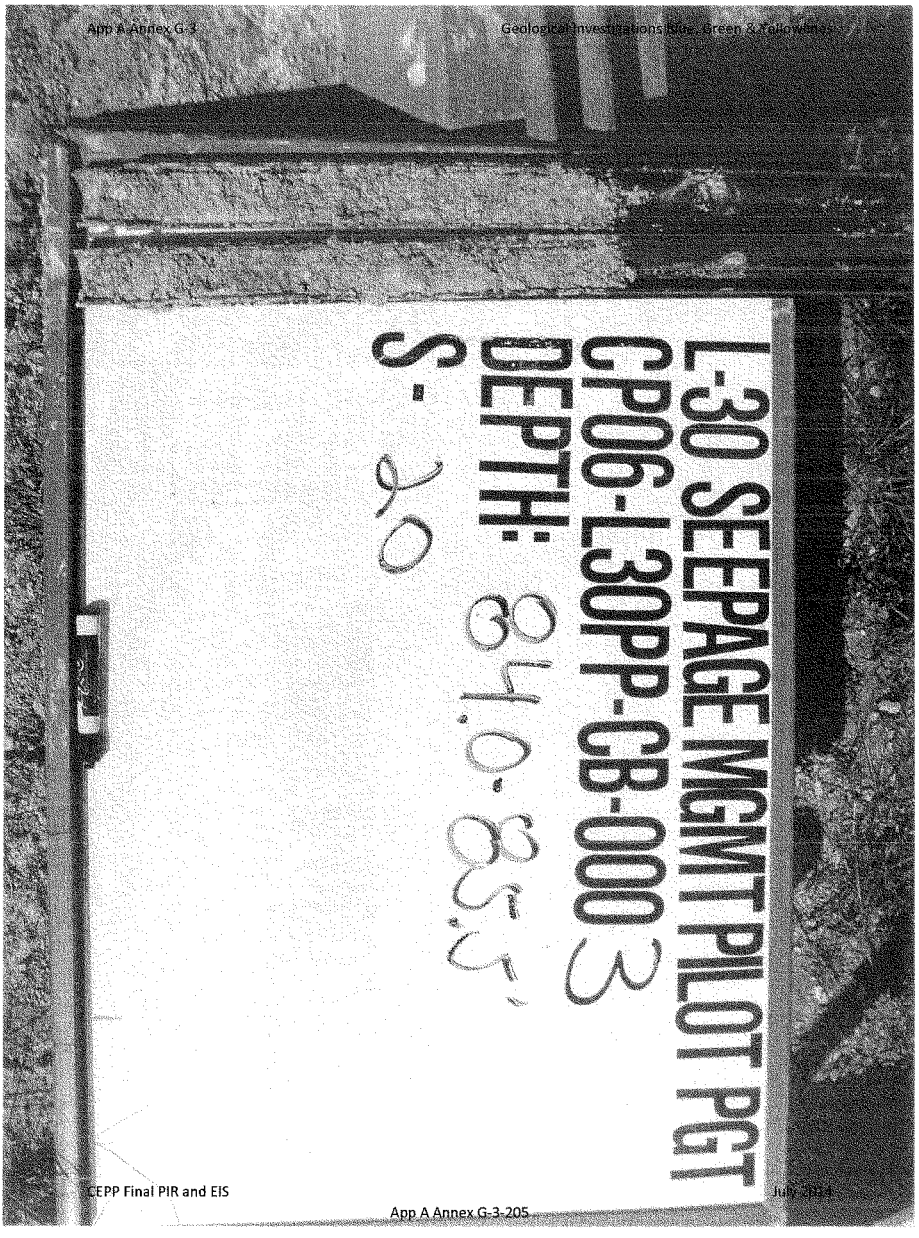

App A Annex G-3
Geological Investigations Blue, Green & Yellow Lines
L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 78.5'-80.0'
S-15
CEPP Final PIR and EIS
App A Annex G-3 200
July 2014

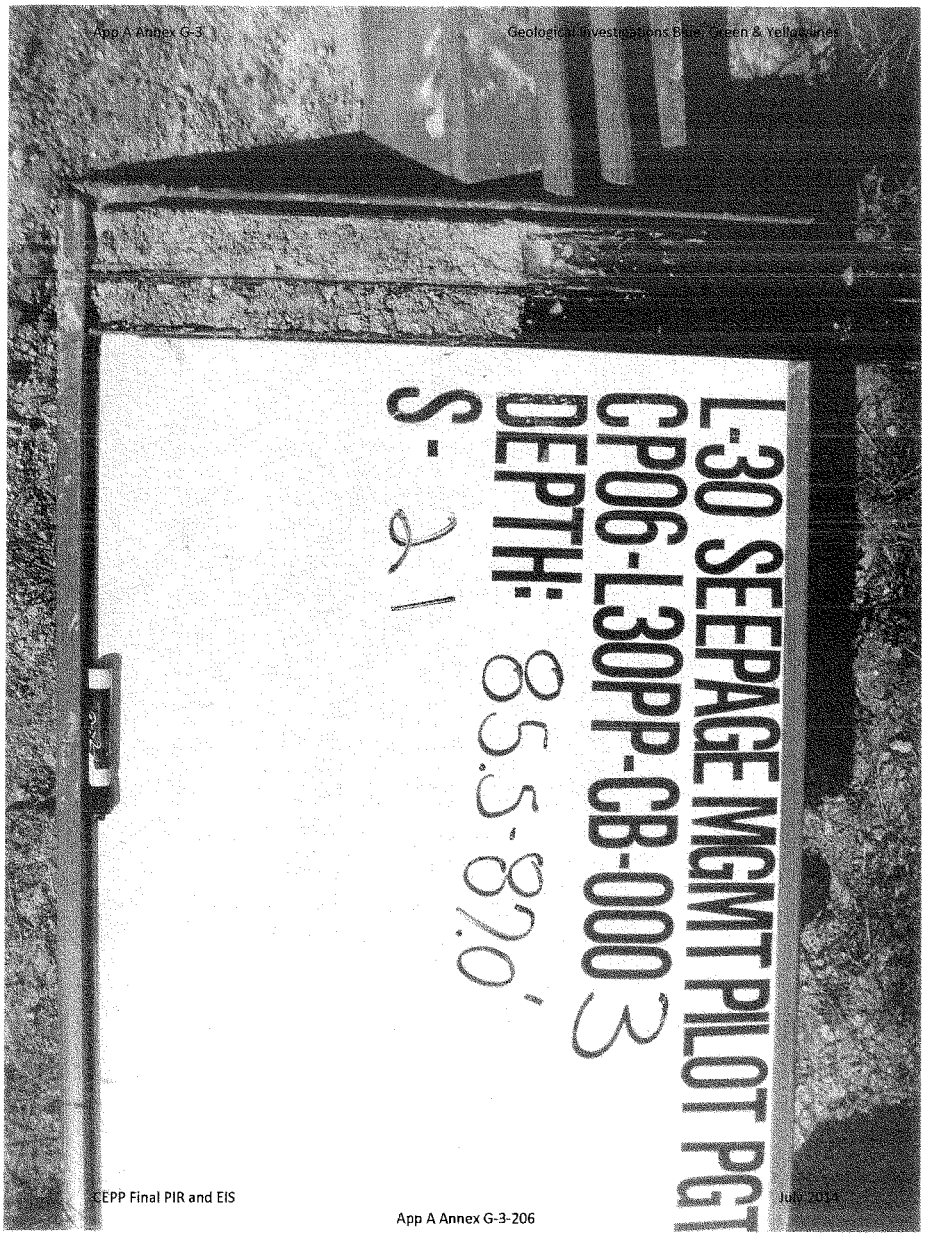

App A Annex G-3
Geological Investigations Rule, Creek & Yellowtail
L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 180-795
S- 16
CERP Final PIR and EIS
App A Annex G-3-201
July 2014

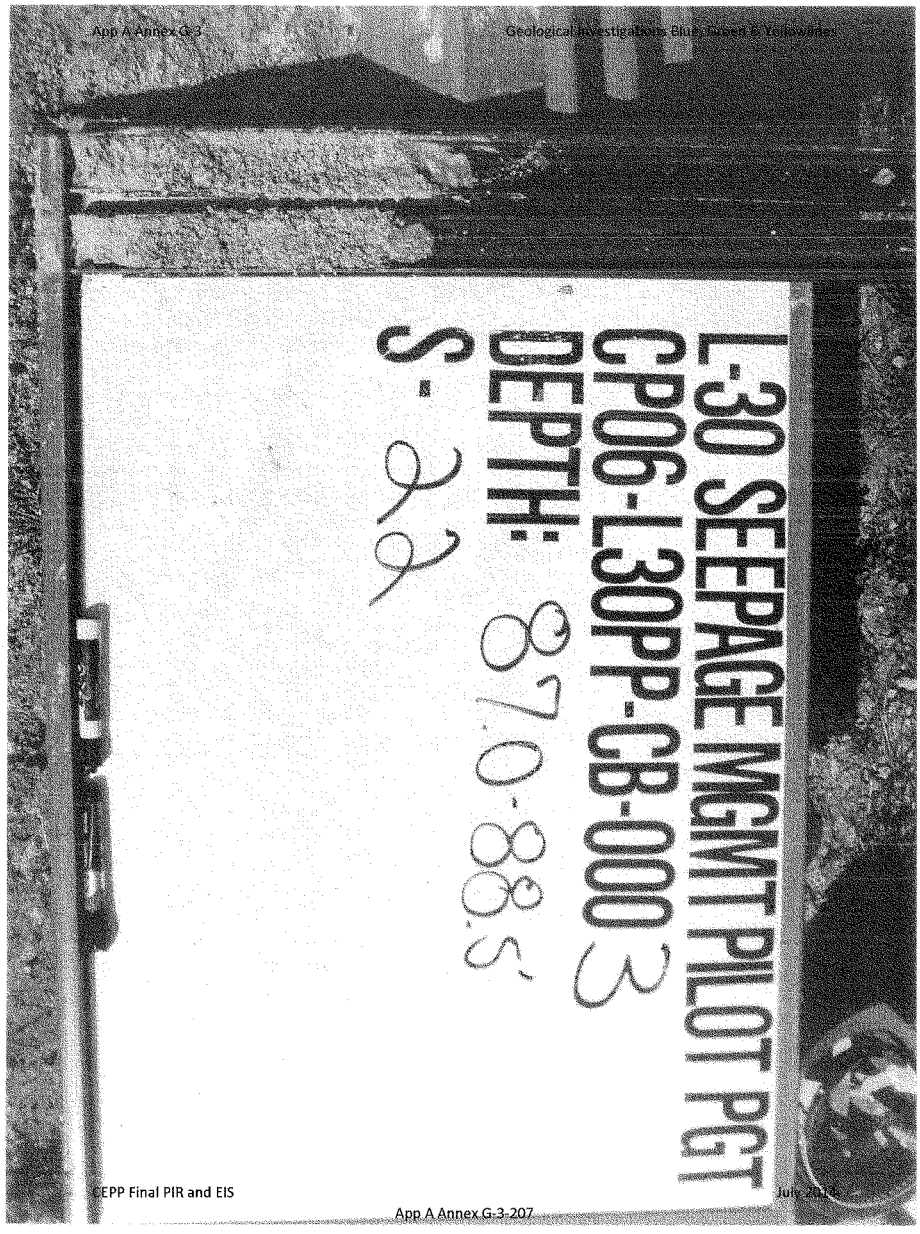

L-30 SEEPAGE MGMT PILOT PC
CP06-L30PP-CB-0003
DEPTH: 79.5-81.0'
S-17

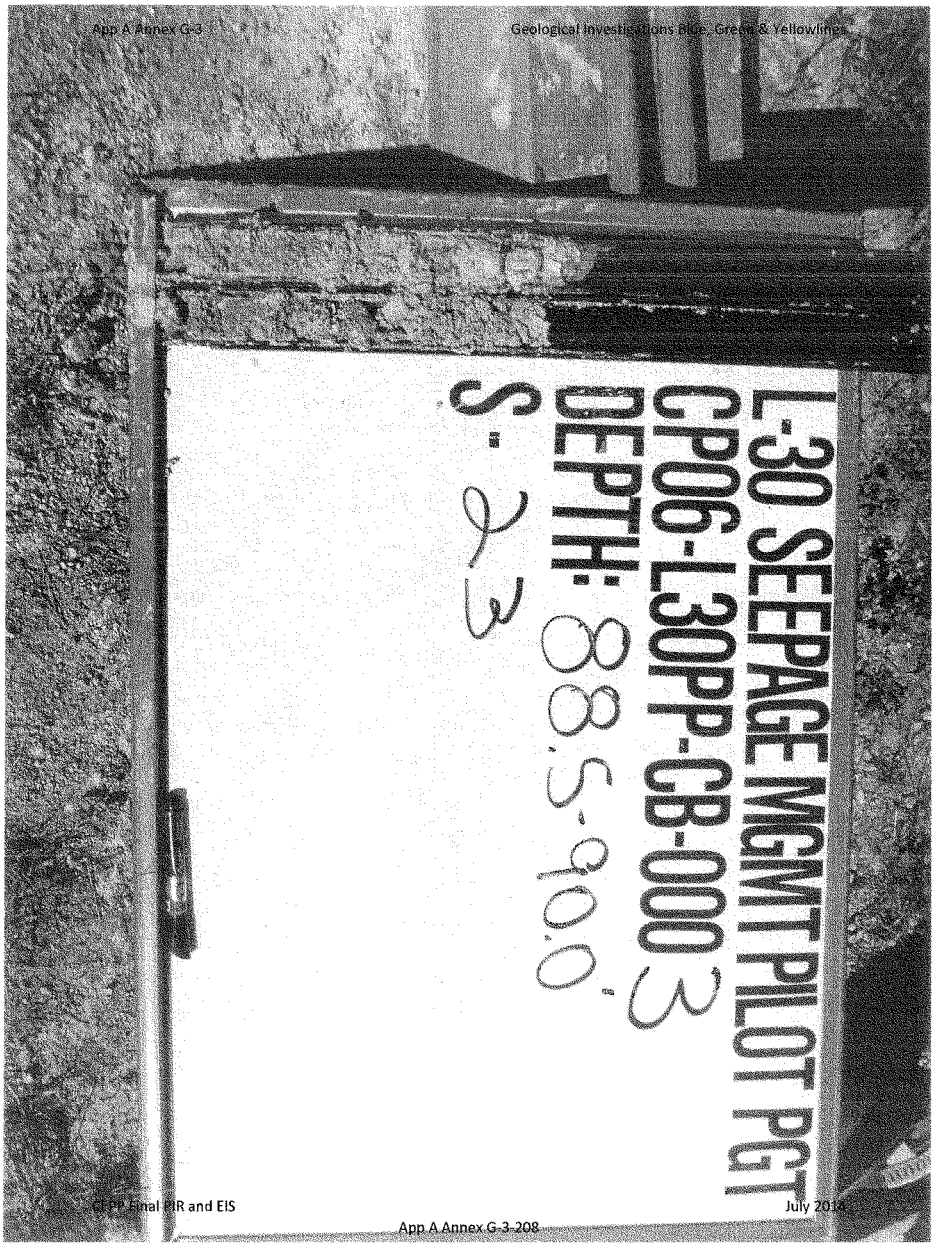

App A Annex G-3
Geological Investigations Blue, Green & Yellowlines
L-30 SEEPAGE MGMT PILOT PGT
GP06-L30PP-CB-0003
DEPTH: 81.0-82.5'
S-18

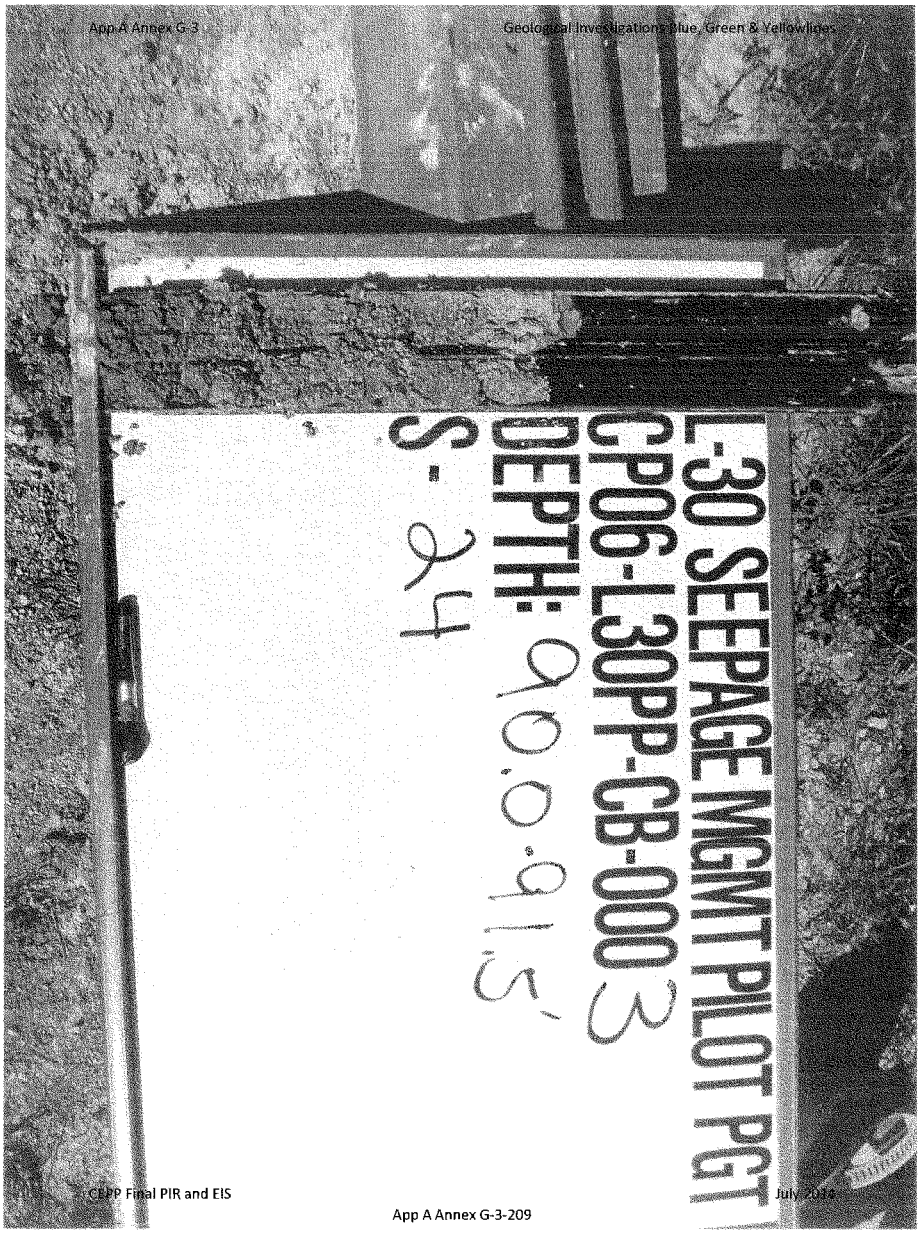

L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 83.5-84.0
S-19


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 80 to 85'
S-90

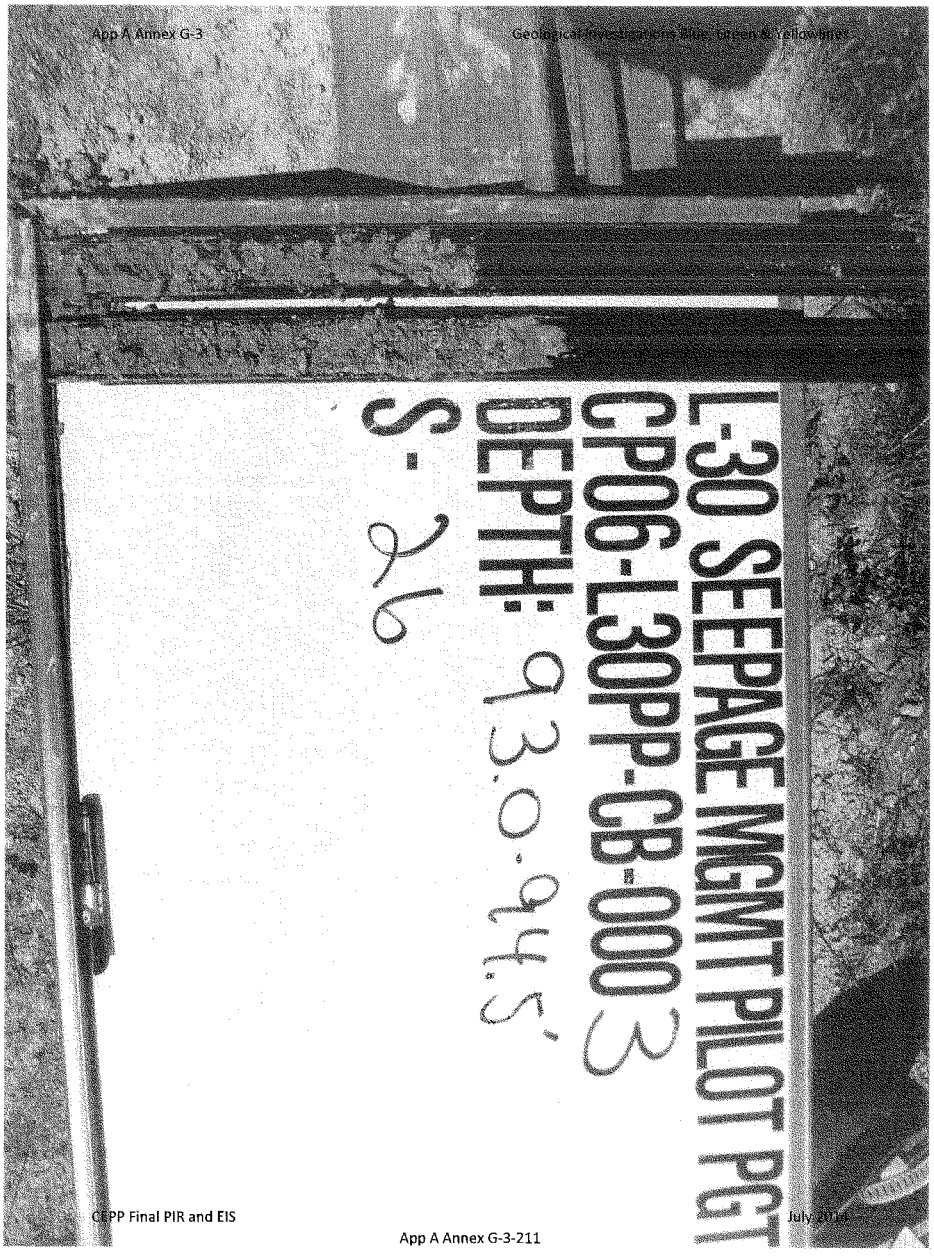

L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 85.5-82.0'
S-9

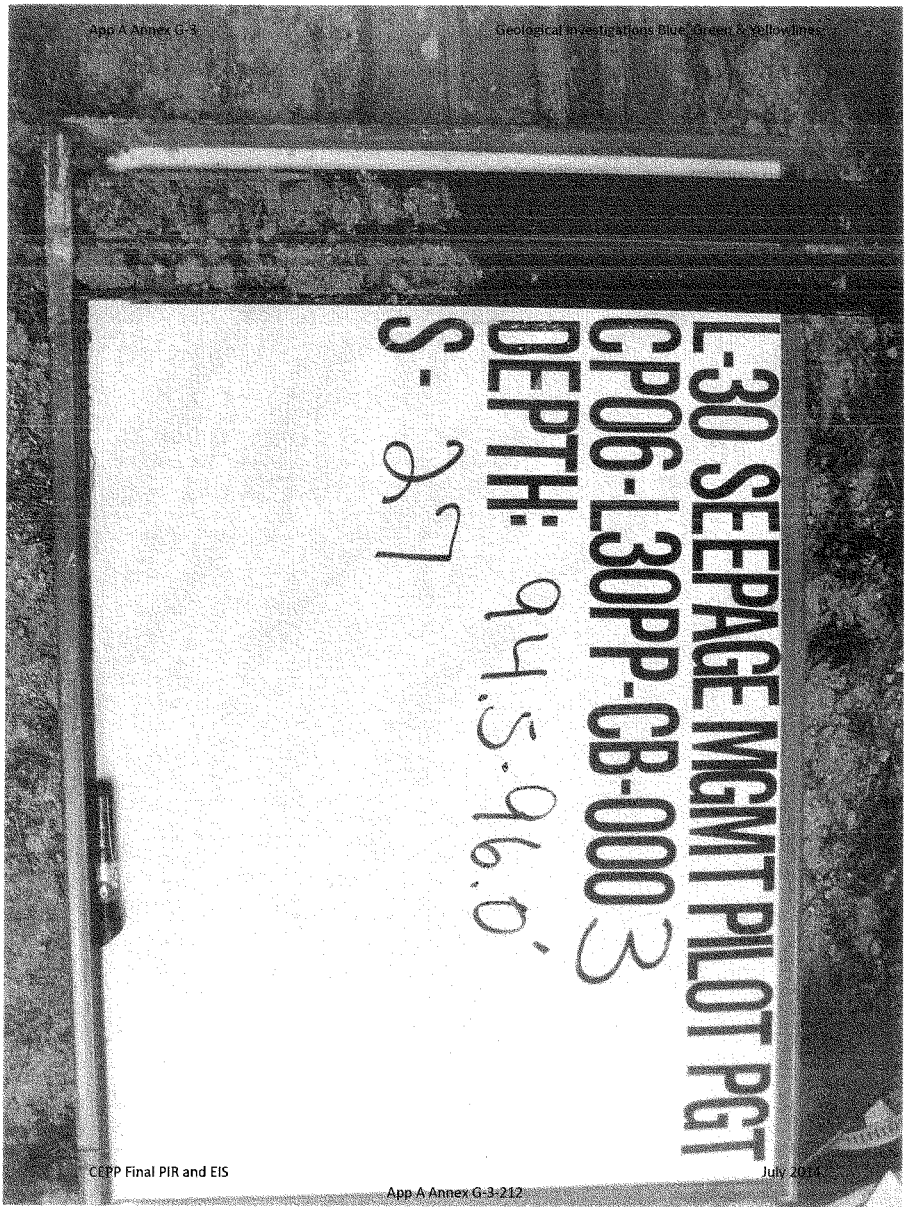

App A Annex G-3
Geological Investigations Bluff Tower 2 Yellowhide
L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 870-885
S.

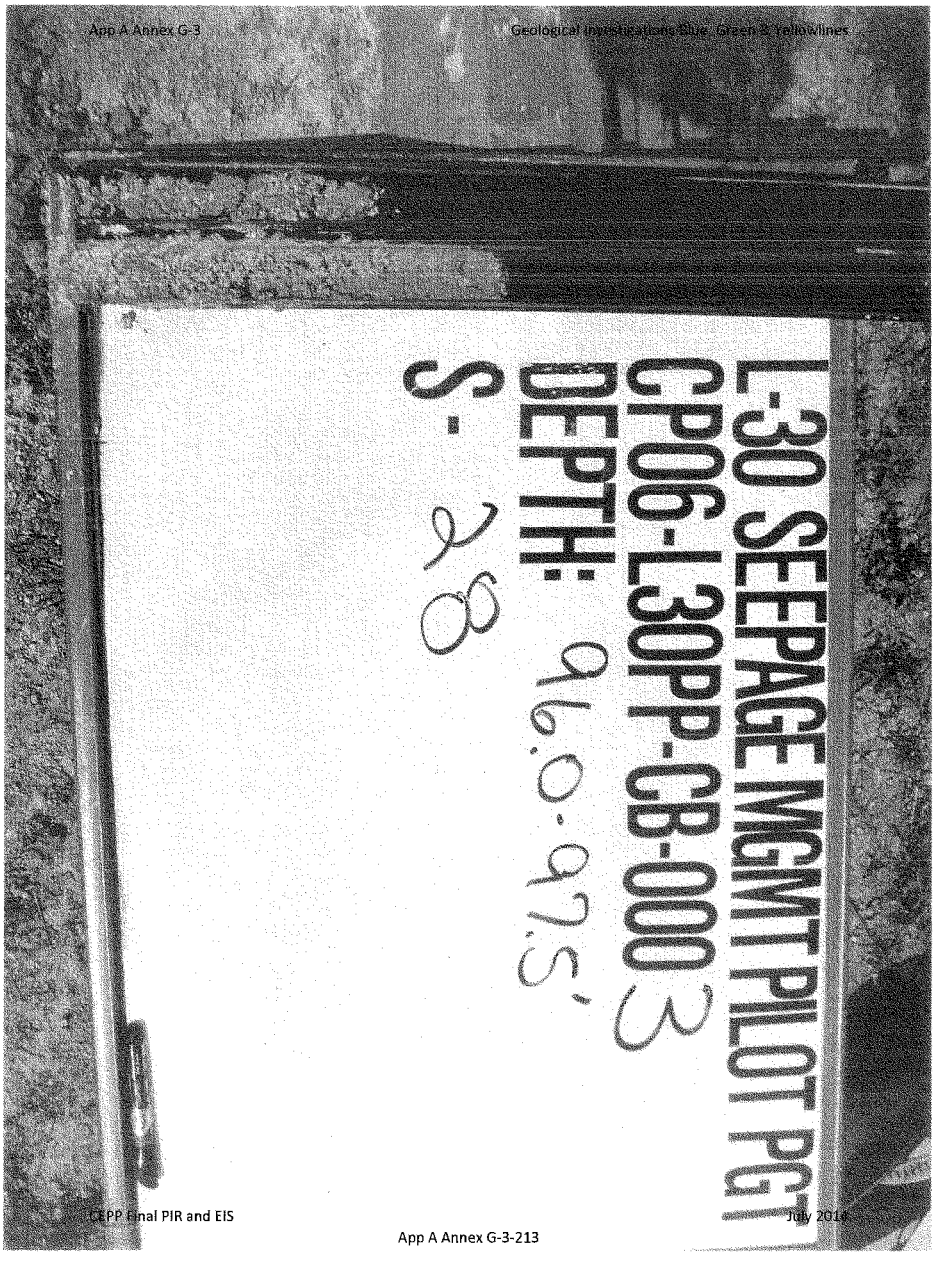

L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 885-900
SITE


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 90.0-91.5
S-34


L-30 SEEPAGE MGMT PILOT P
CP06-L30PP-CB-0003
DEPTH: 915-930'
S-95


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 93.0-94.5'
S-96


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 94.5-96.0
S-7


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 9.0-9.5'
S-2


App A Annex G-3
Borehole at Investigations Area, Green & Yellowlines
L-30 SEEPAGE MGMT PILOT
CP06-L30PP-GB-0003
DEPTH: 975-990'
S.99

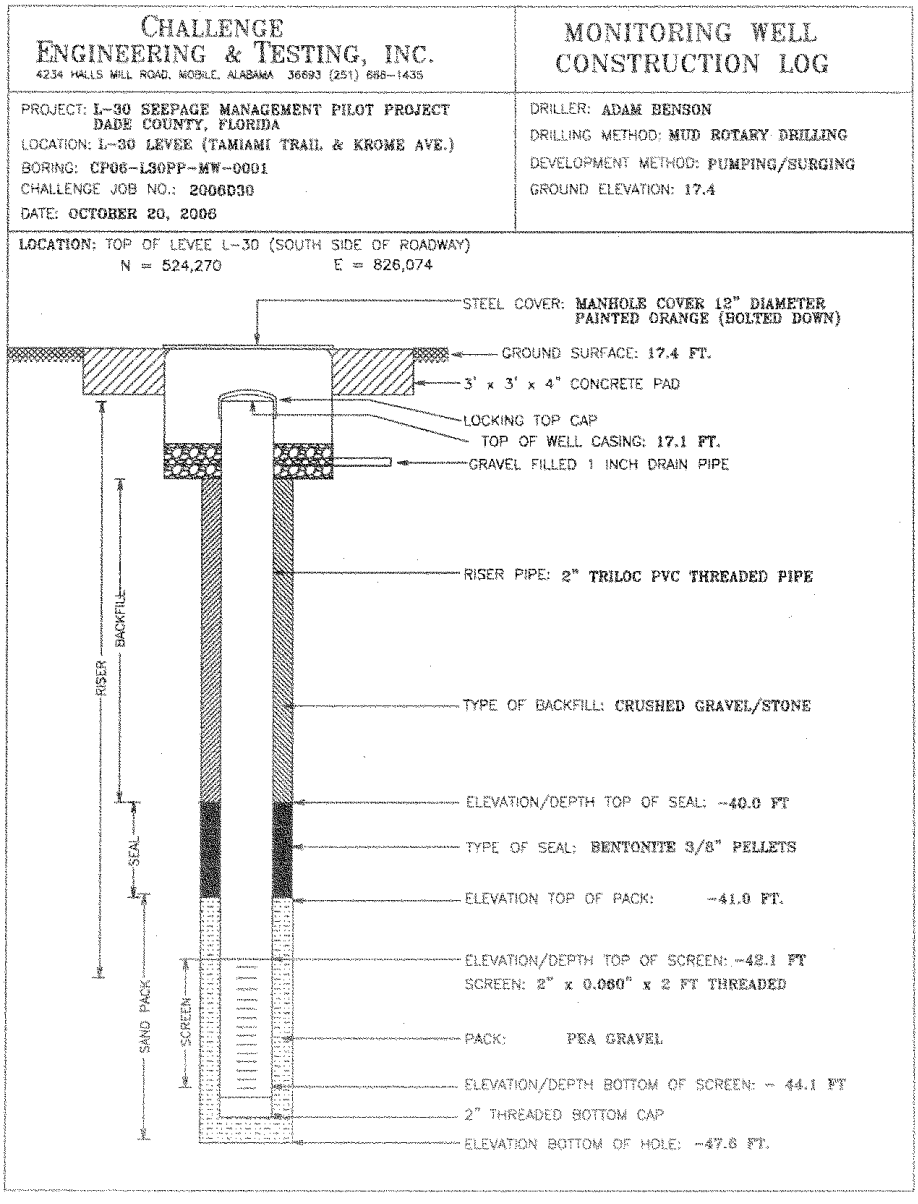

L-30 SEEPAGE MGMT PILOT P
CP06-L30PP-CB-0003
DEPTH: 990-1003'
S.W.O


L-30 SEEPAGE MGMT PILOT PGT
GP06-L30PP-CB-0003
DEPTH: 100.5-102.0
S. 3-1

L30 SEEPAGE MGMT PILOT
PROG: L30PP-CR-0003
DEPTH: 10 to 20 ft
S.W.


L-30 SEEPAGE MGMT PILOT PGT
CP06-L30PP-CB-0003
DEPTH: 103.5-105.0
S. 3 3

MONITORING WELL CONSTRUCTION DIAGRAMS


CHALLENGE ENGINEERING & TESTING, INC.
4234 HALLS MILL ROAD, MOBILE, ALABAMA 36693 (251) 666-1435
MONITORING WELL CONSTRUCTION LOG
PROJECT: L-30 SEEPAGE MANAGEMENT PILOT PROJECT DADE COUNTY, FLORIDA
LOCATION: L-30 LEVEE (TAMIAMI TRAIL & KROME AVE.)
BORING: CP06-L30PP-MW-0001
CHALLENGE JOB NO.: 2006030
DATE: OCTOBER 20, 2006
DRILLER: ADAM BENSON
DRILLING METHOD: MUD ROTARY DRILLING
DEVELOPMENT METHOD: PUMPING/SURGING
GROUND ELEVATION: 17.4
LOCATION: TOP OF LEVEE L-30 (SOUTH SIDE OF ROADWAY)
N = 524,270 E = 826,074
STEEL COVER: MANHOLE COVER 12" DIAMETER PAINTED ORANGE (BOLTED DOWN)
GROUND SURFACE: 17.4 FT.
3' x 3' x 4" CONCRETE PAD
LOCKING TOP CAP
TOP OF WELL CASING: 17.1 FT.
GRAVEL FILLED 1 INCH DRAIN PIPE
RISER PIPE: 2" TRILOC PVC THREADED PIPE
TYPE OF BACKFILL: CRUSHED GRAVEL/STONE
ELEVATION/DEPTH TOP OF SEAL: -40.0 FT
TYPE OF SEAL: BENTONITE 3/8" PELLETS
ELEVATION TOP OF PACK: -41.0 FT.
ELEVATION/DEPTH TOP OF SCREEN: -42.1 FT
SCREEN: 2" x 0.060" x 2 FT THREADED
PACK: PEA GRAVEL
ELEVATION/DEPTH BOTTOM OF SCREEN: - 44.1 FT
2" THREADED BOTTOM CAP
ELEVATION BOTTOM OF HOLE: -47.6 FT.
RISER
BACKFILL
SEAL
SAND PACK
SCREEN

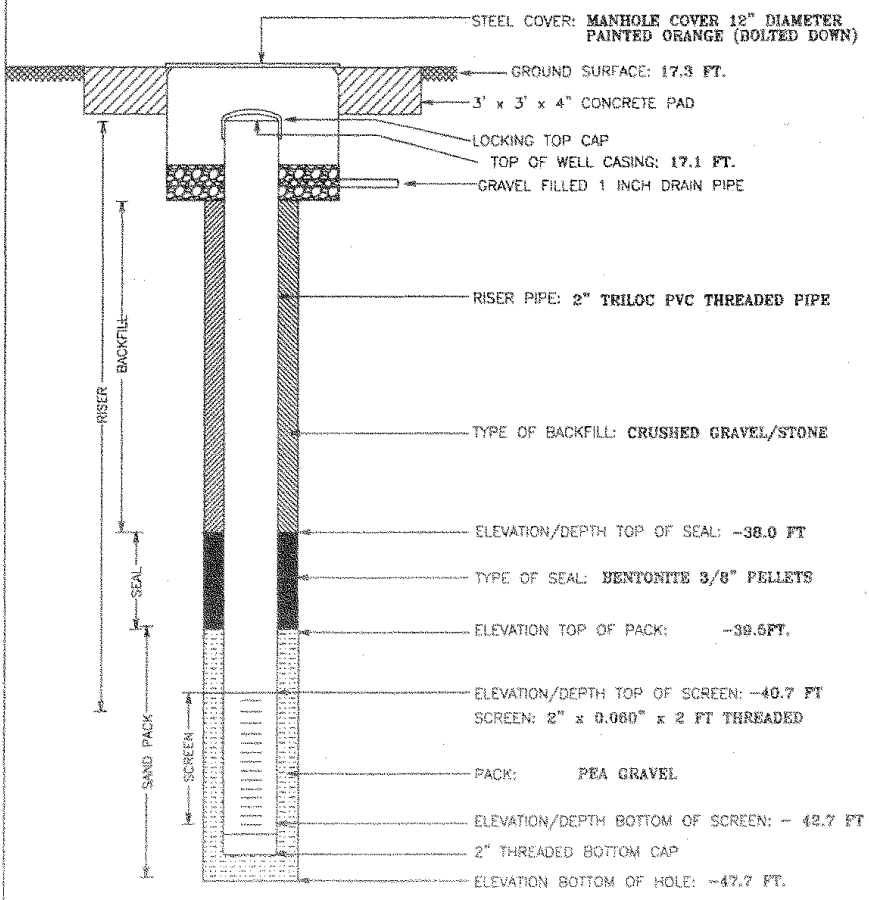
CHALLENGE ENGINEERING & TESTING, INC.
4234 HALLS MILL ROAD, MOBILE, ALABAMA 36693 (251) 666-1435

MONITORING WELL CONSTRUCTION LOG

PROJECT: L-30 SEEPAGE MANAGEMENT PILOT PROJECT
DADE COUNTY, FLORIDA
LOCATION: L-30 LEVEE (TAMIAMI TRAIL & KROME AVE.)
BORING: CP06-L30FP-MW-0002
CHALLENGE JOB NO.: 2006D30
DATE: OCTOBER 20, 2006

DRILLER: ADAM BENSON
DRILLING METHOD: MUD ROTARY DRILLING
DEVELOPMENT METHOD: PUMPING/SURGING
GROUND ELEVATION: 17.3 FT. NAVD88

LOCATION: TOP OF LEVEE L-30 (SOUTH SIDE OF ROADWAY)
N = 522,036 E = 823,754



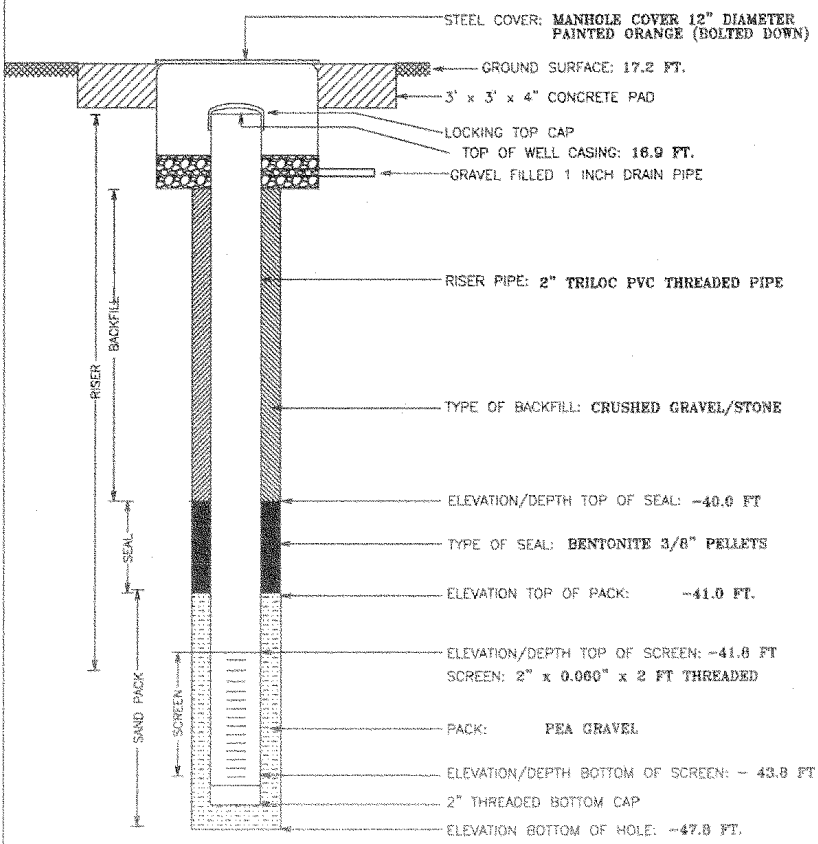
CHALLENGE ENGINEERING & TESTING, INC.
4234 HALLS MILL ROAD, MOBILE, ALABAMA 36693 (251) 666-1435

MONITORING WELL CONSTRUCTION LOG

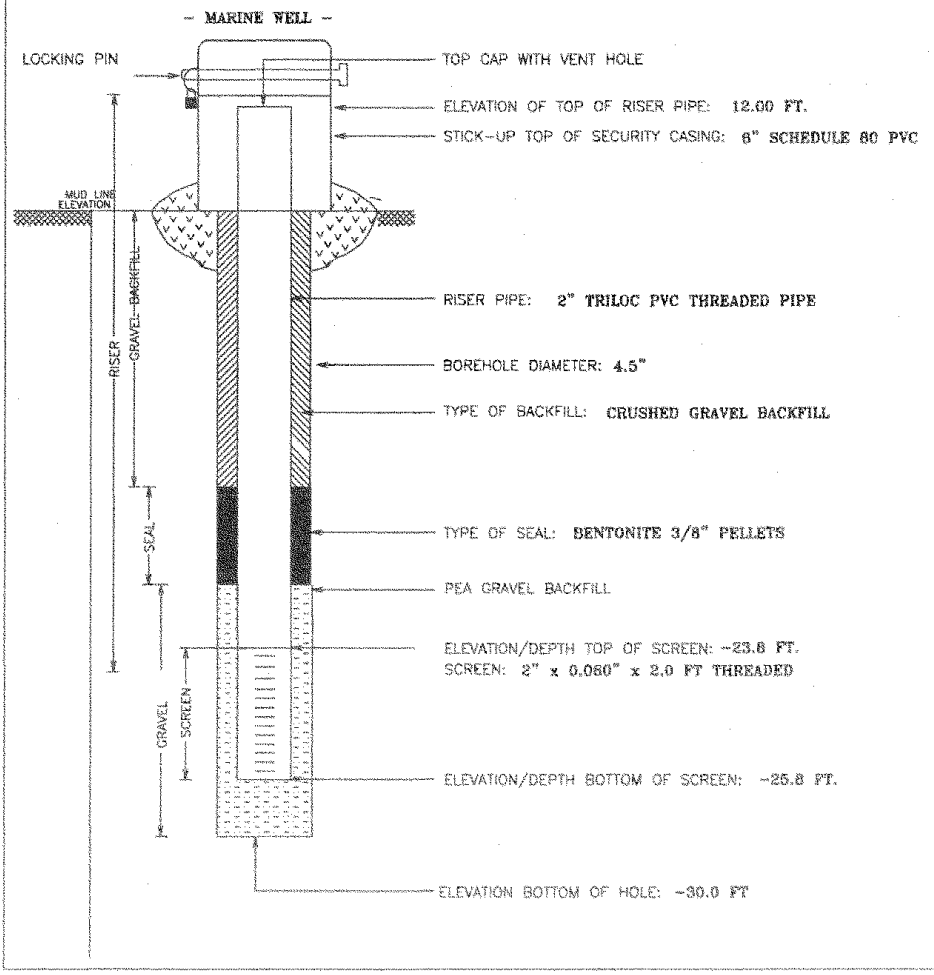
PROJECT: L-30 SEEPAGE MANAGEMENT PILOT PROJECT
DADE COUNTY, FLORIDA
LOCATION: L-30 LEVEE (TAMIAMI TRAIL & KROME AVE.)
BORING: CP66-L30PP-MW-0003
CHALLENGE JOB NO.: 2006D30
DATE: OCTOBER 20, 2006

DRILLER: ADAM BENSON
DRILLING METHOD: MUD ROTARY DRILLING
DEVELOPMENT METHOD: PUMPING/SURGING
GROUND ELEVATION: 17.2 FT. NAVD88

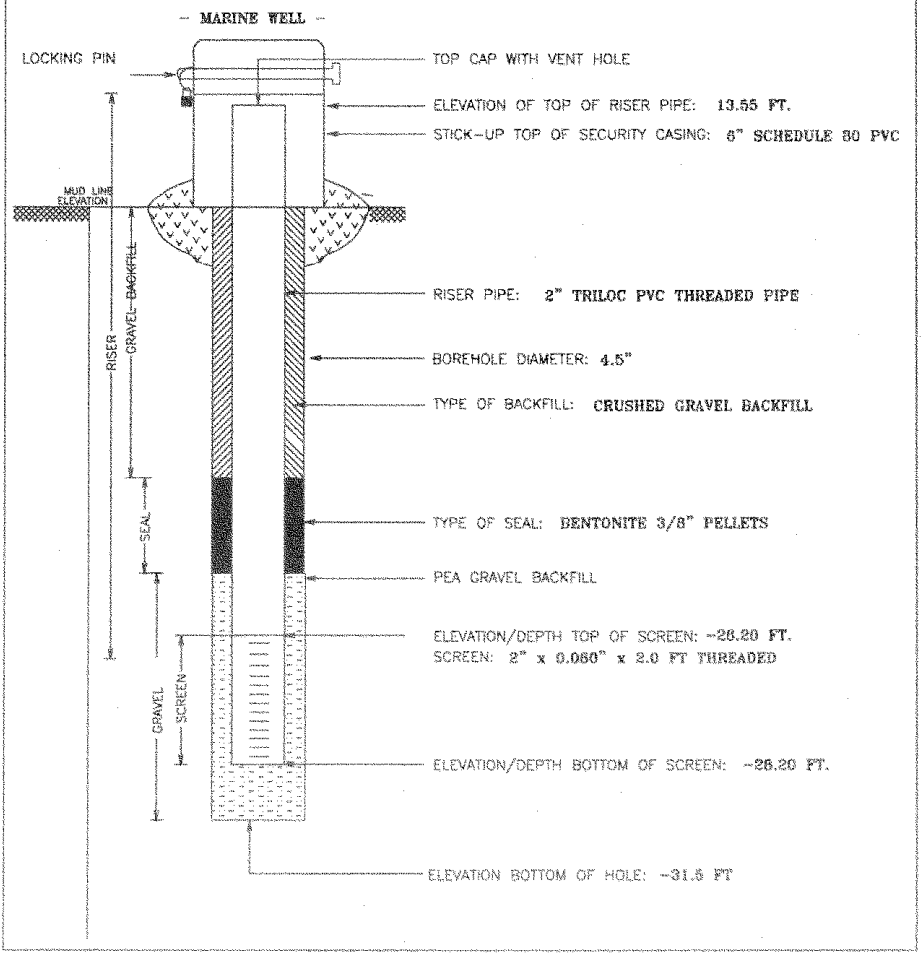
LOCATION: TOP OF LEVEE L-30 (SOUTH SIDE OF ROADWAY)
N = 519,734 E = 821,356



CHALLENGE ENGINEERING & TESTING, INC. 4254 HALLS MILL ROAD, MOBILE, ALABAMA 36693 (251) 666-1435	MONITORING WELL CONSTRUCTION LOG
PROJECT: L-30 SEEPAGE MANAGEMENT PILOT PROJECT LOCATION: DADE COUNTY, FL (TAMIAMI TRAIL & KROME AVE.) BORING: CP06-L30PP-MW-0004 CHALLENGE JOB NO.: 2006D30 DATE: NOVEMBER 2006	DRILLER: ADAM BENSON DRILLING METHOD: ROLLER BIT - WET ROTARY DEVELOPMENT METHOD: PUMPING/SURGING TOP OF CASING: 12.00 FT. FIELD GEOLOGIST: BOB MOMBERGER, P.G.

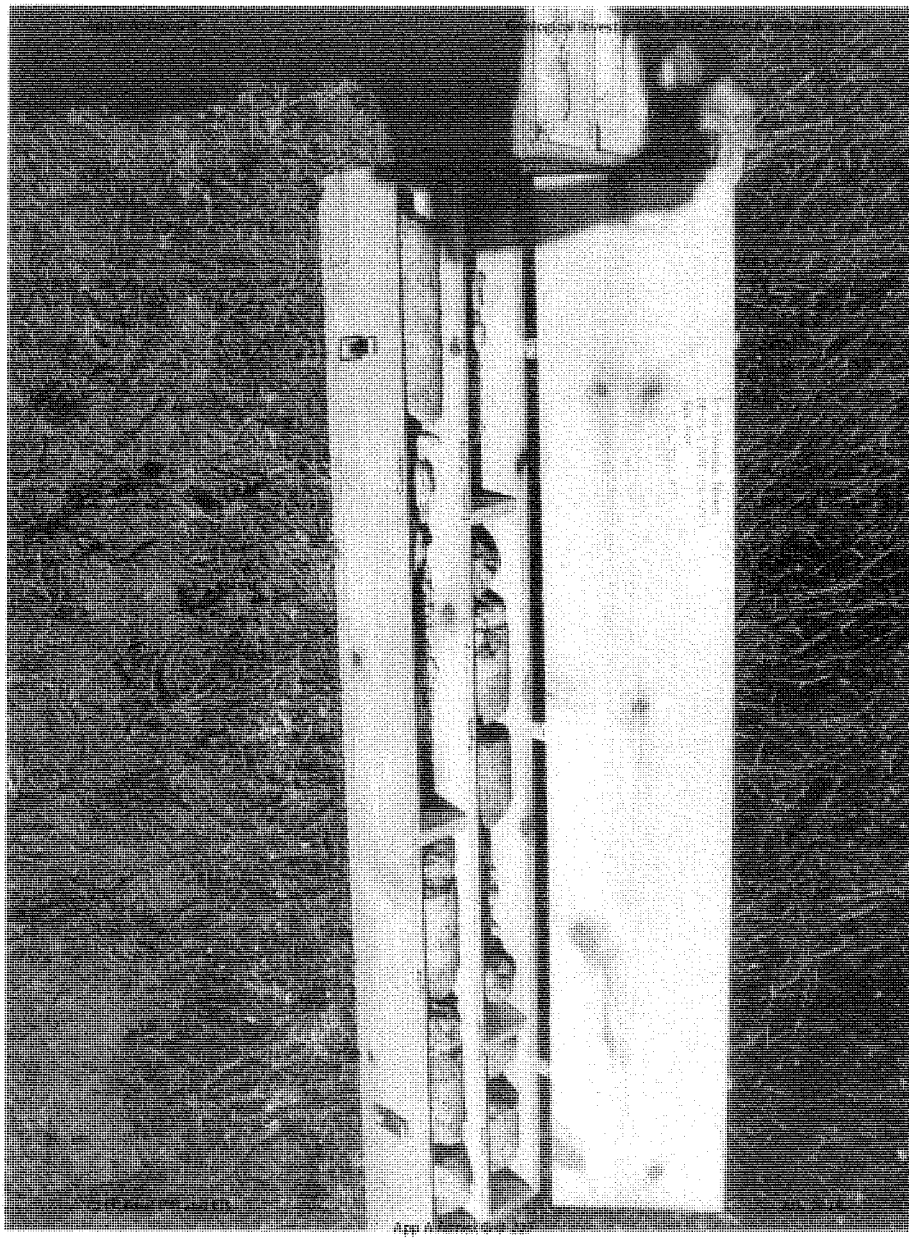


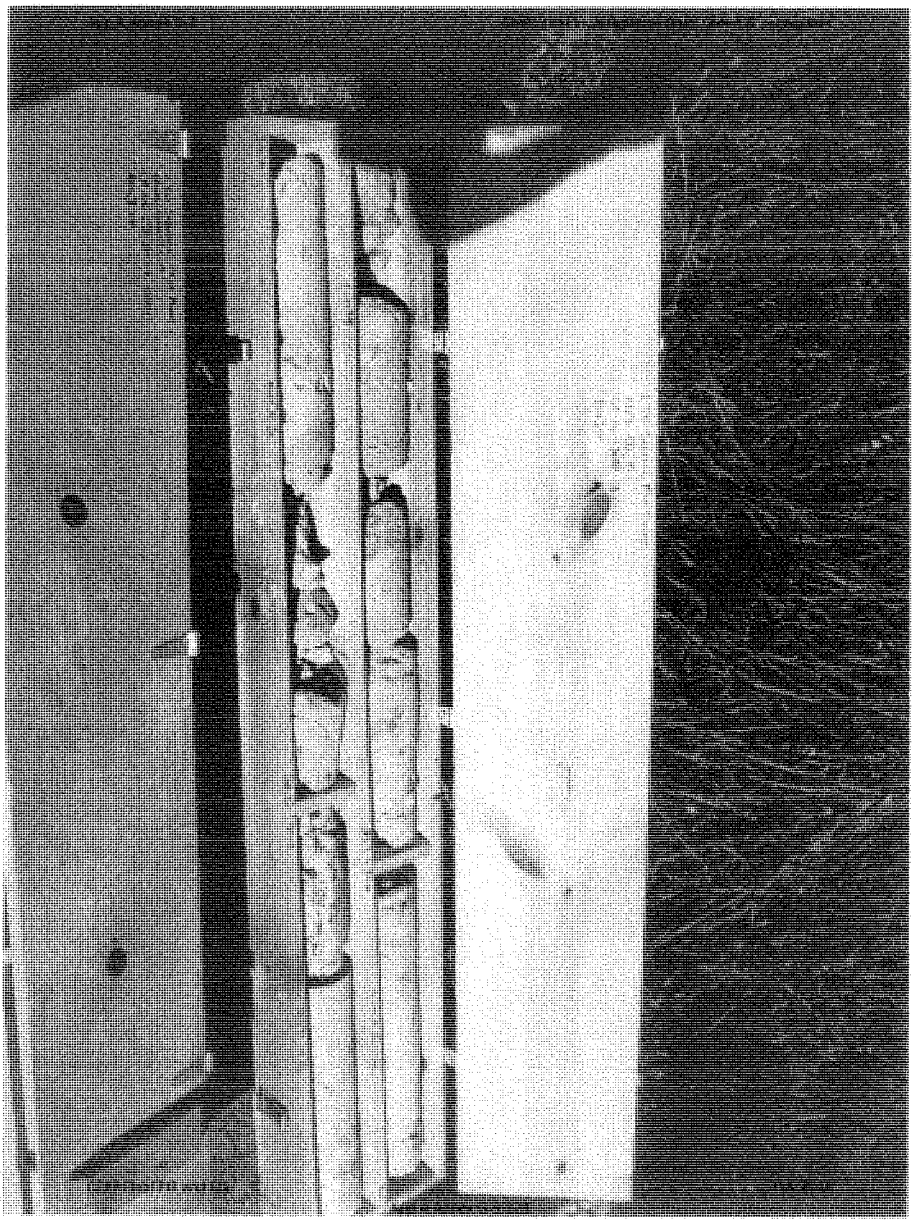
CHALLENGE ENGINEERING & TESTING, INC. 4234 HALLS MILL ROAD, MOBILE, ALABAMA 36693 (251) 666-1435	MONITORING WELL CONSTRUCTION LOG
PROJECT: L-30 SEEPAGE MANAGEMENT PILOT PROJECT LOCATION: DADE COUNTY, FL (TAMIAMI TRAIL & KROME AVE.) BORING: CP06-L30PP-MW-0005 CHALLENGE JOB NO.: 2006D30 DATE: NOVEMBER 2006	DRILLER: ADAM BENSON DRILLING METHOD: ROLLER BIT - WET ROTARY DEVELOPMENT METHOD: PUMPING/SURGING TOP OF CASING: 13.55 FT. FIELD GEOLOGIST: BOB MOMBERGER, P.G.

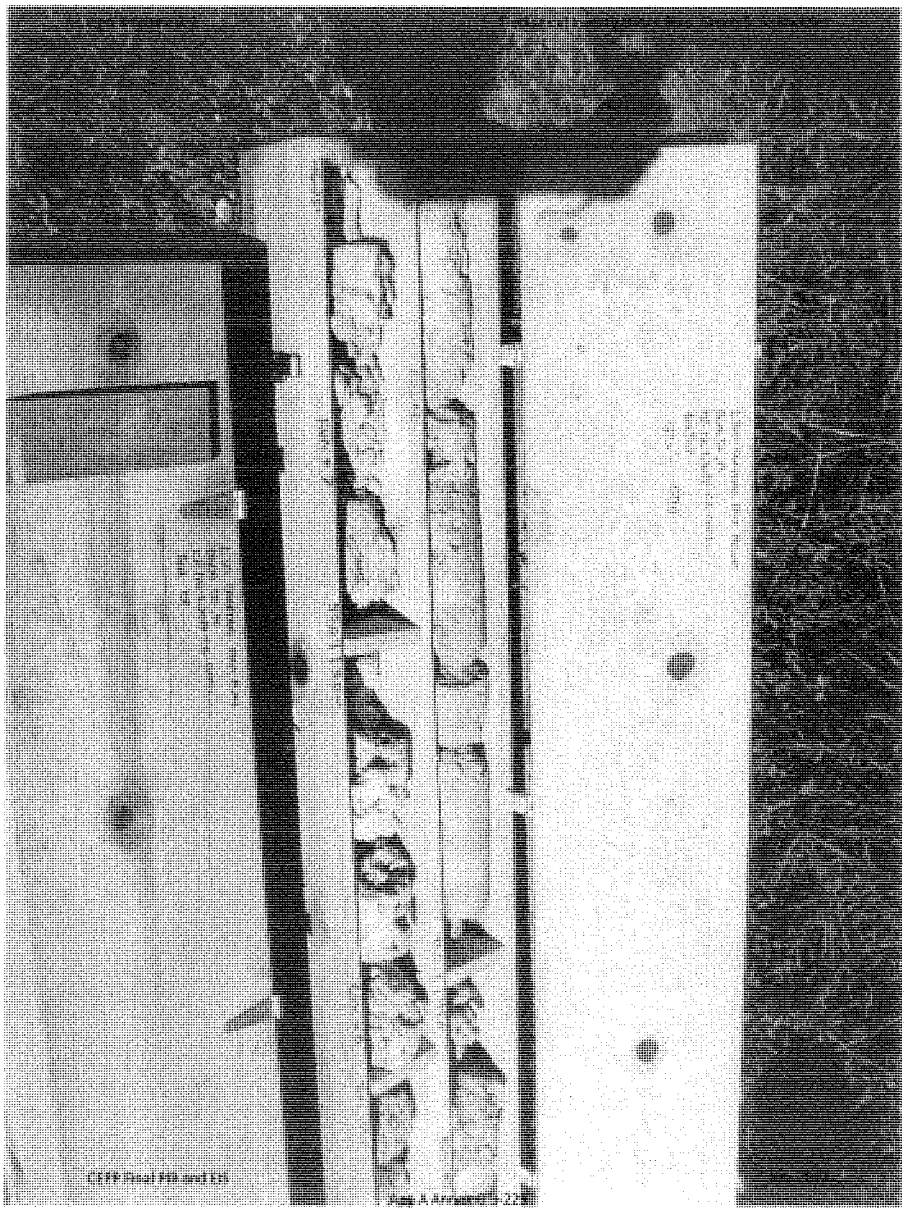


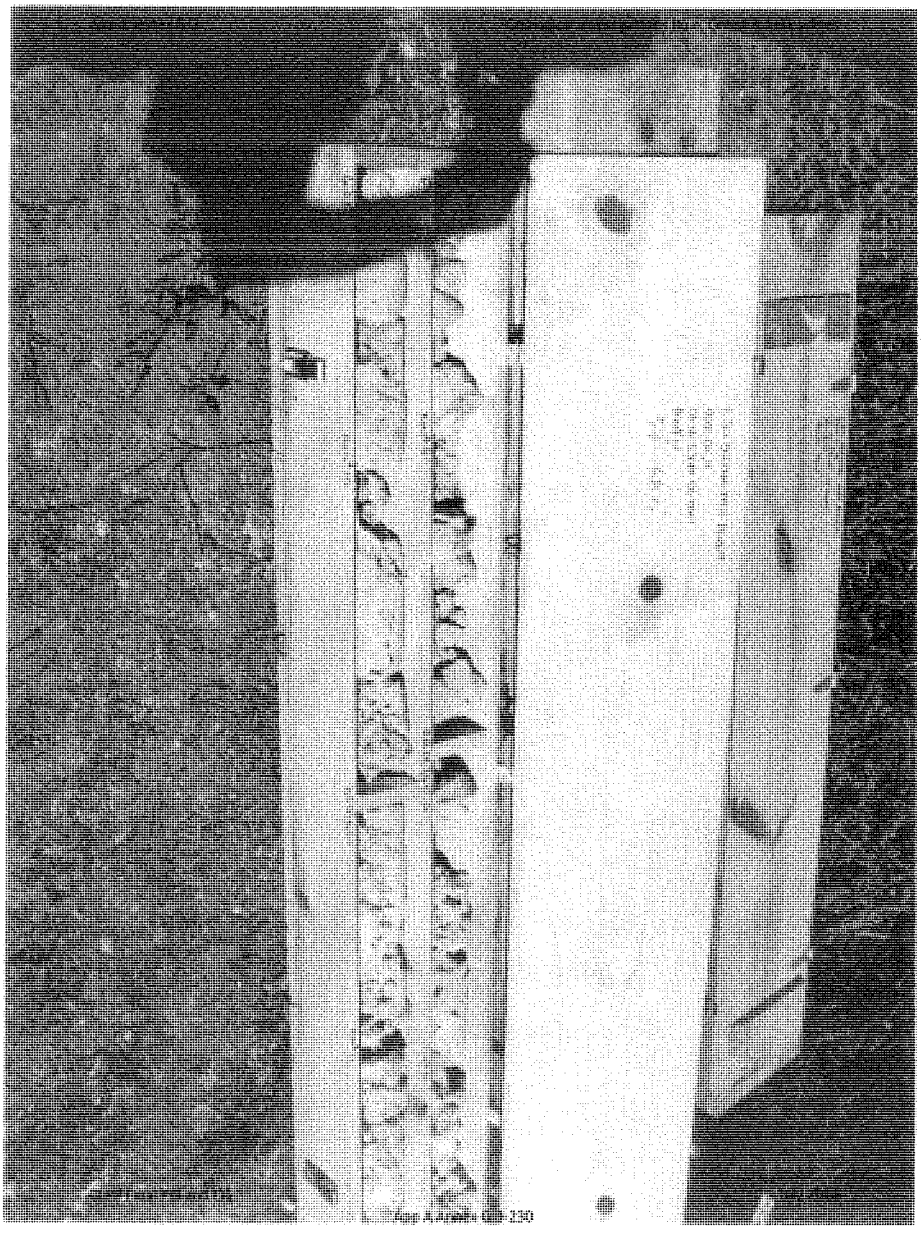
CORE BOX INVENTORY REPORT & PHOTOGRAPHS

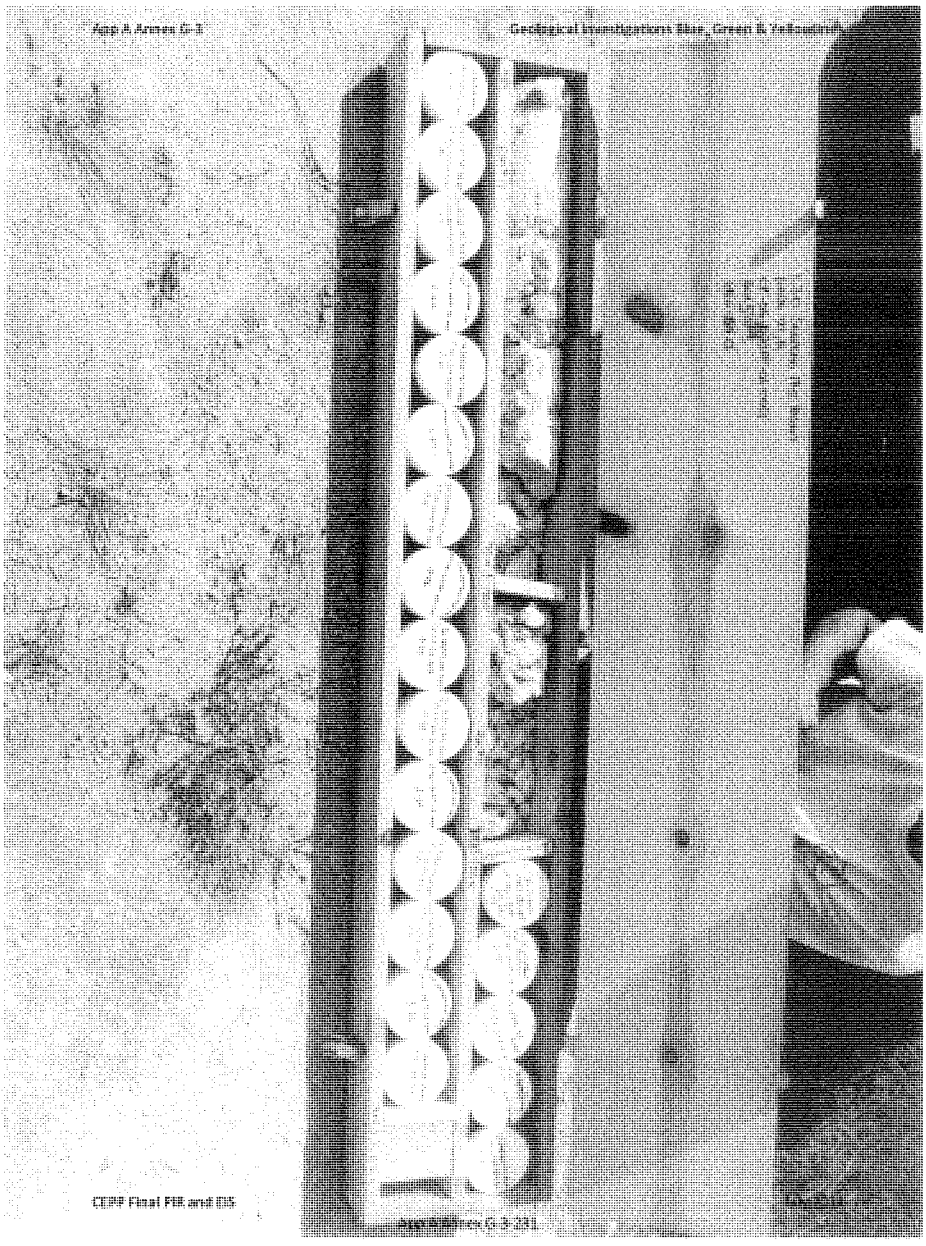


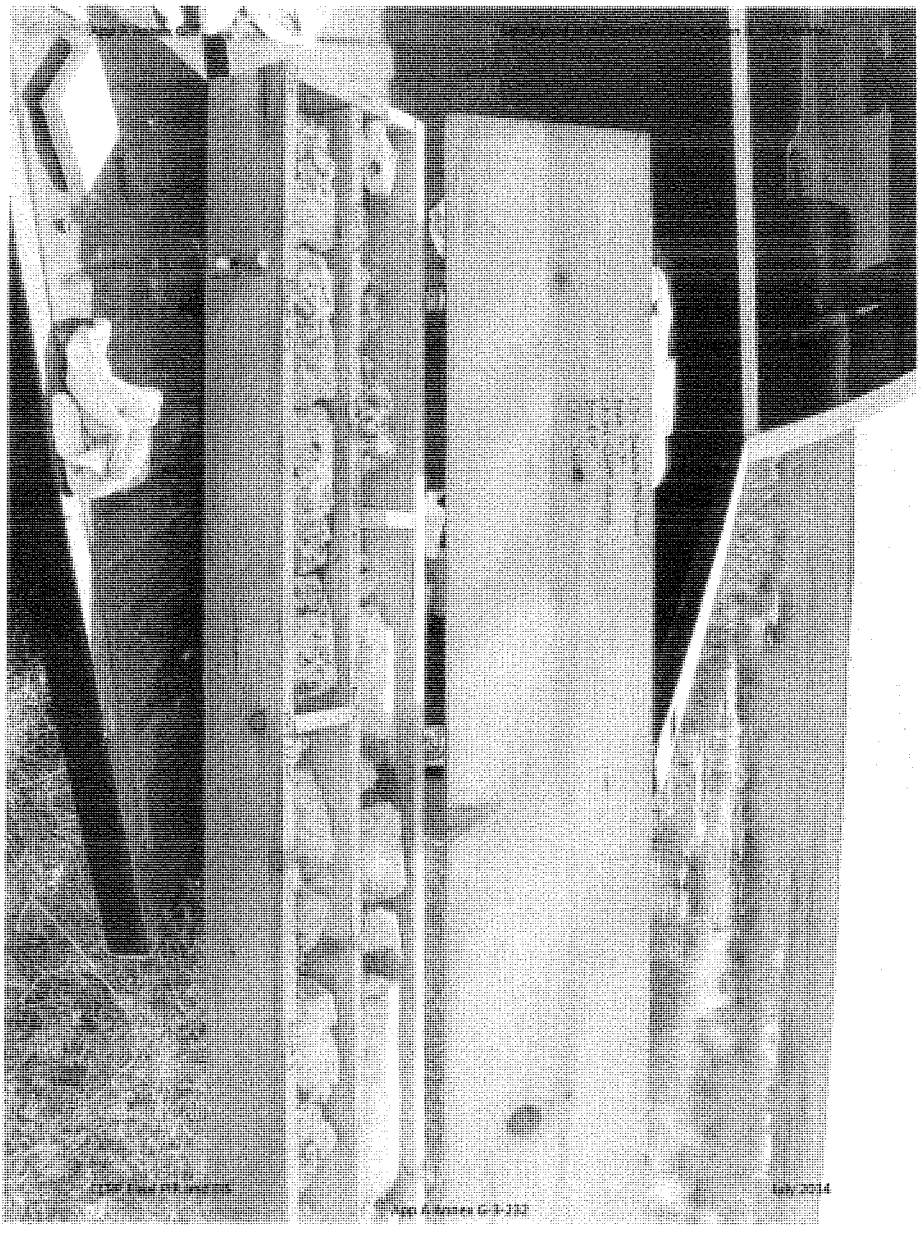


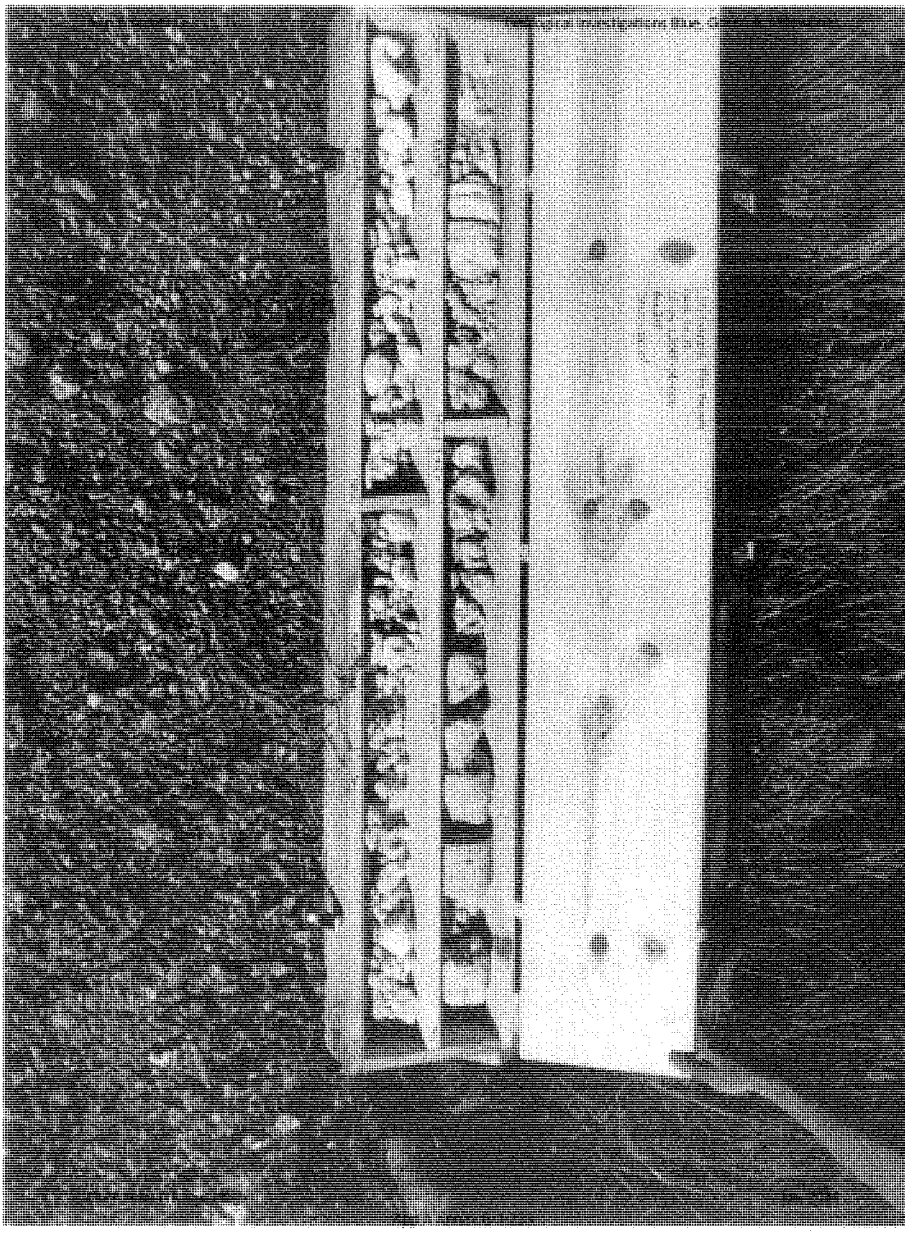


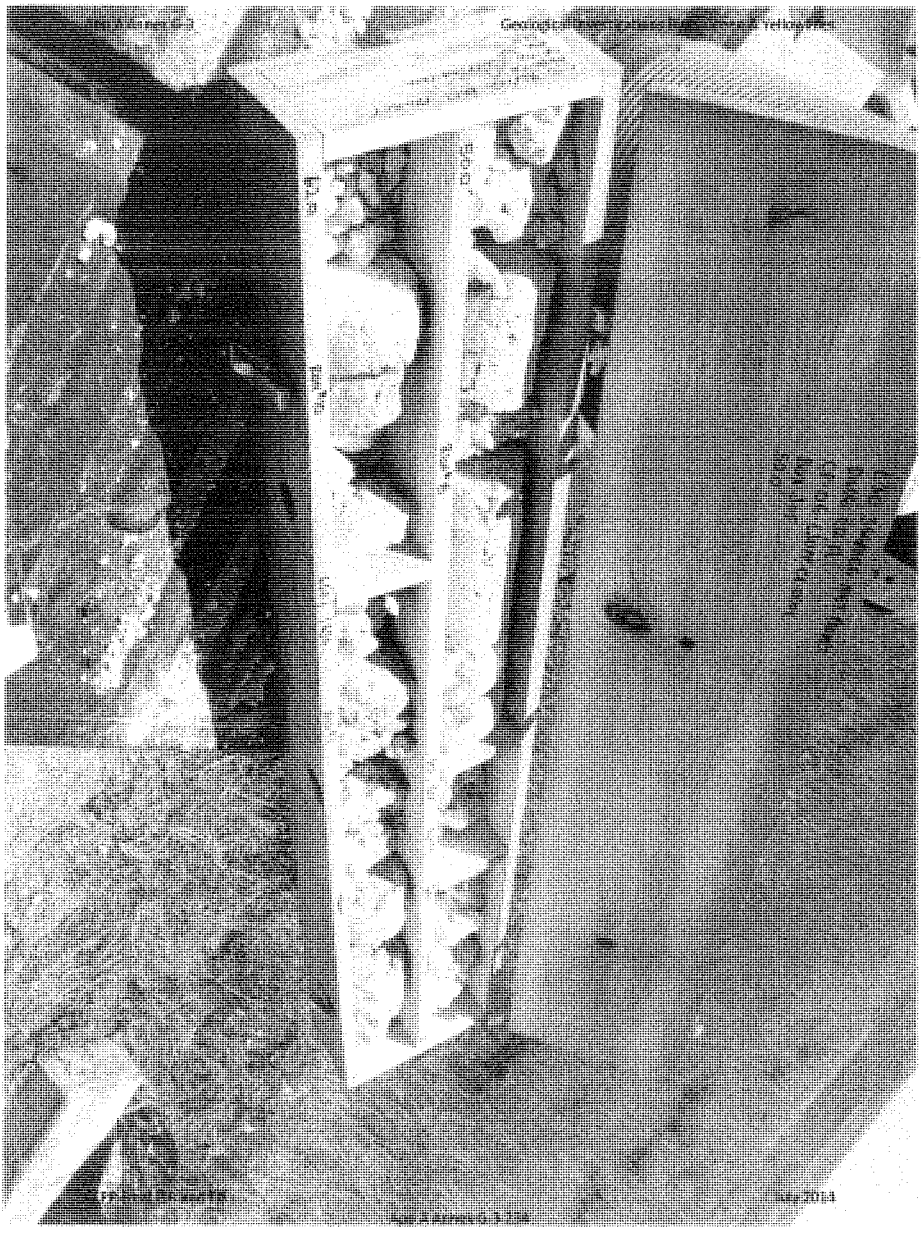


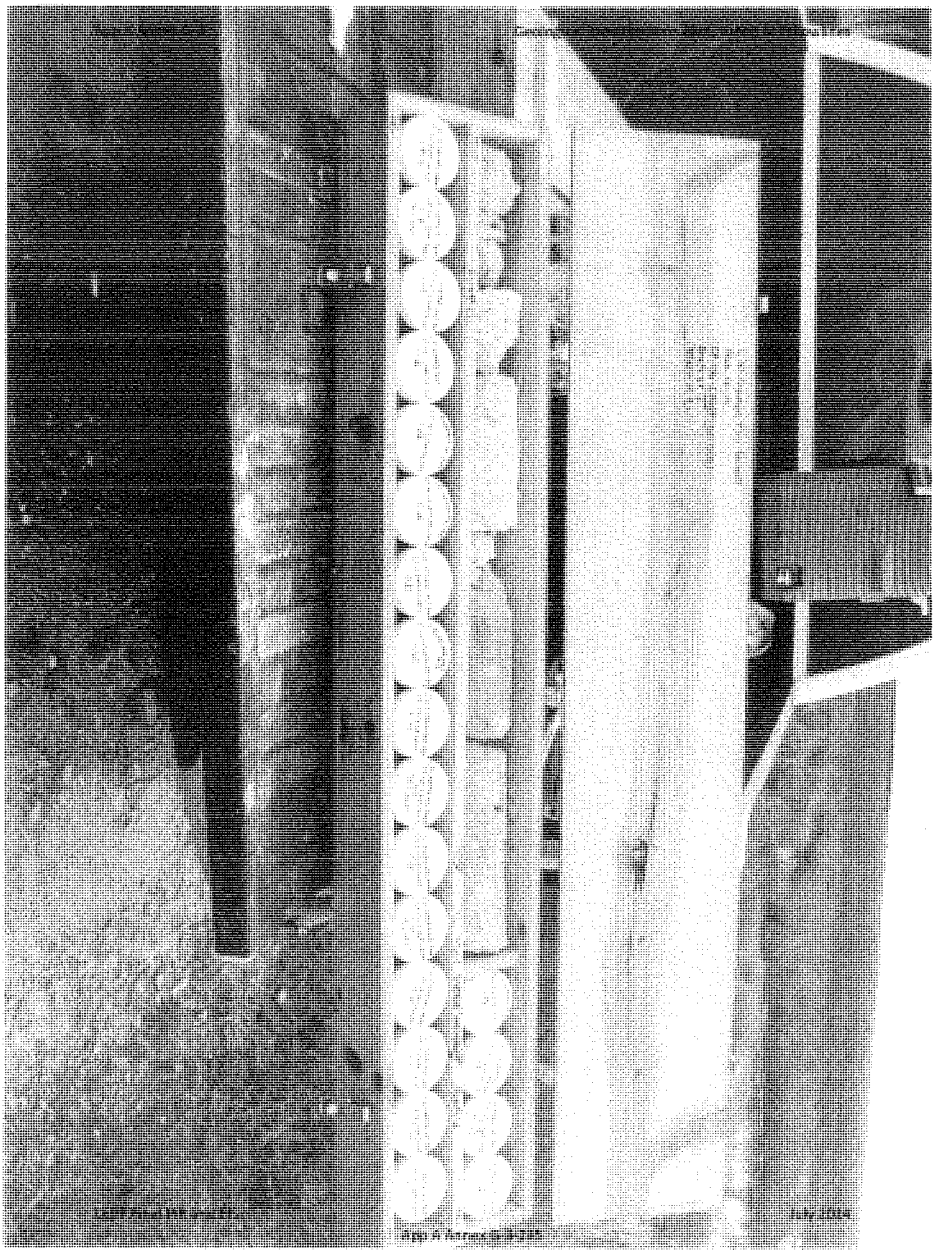



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Geological Investigations Blue, Green & Yellowstone
CEPF Final FIR and EIS
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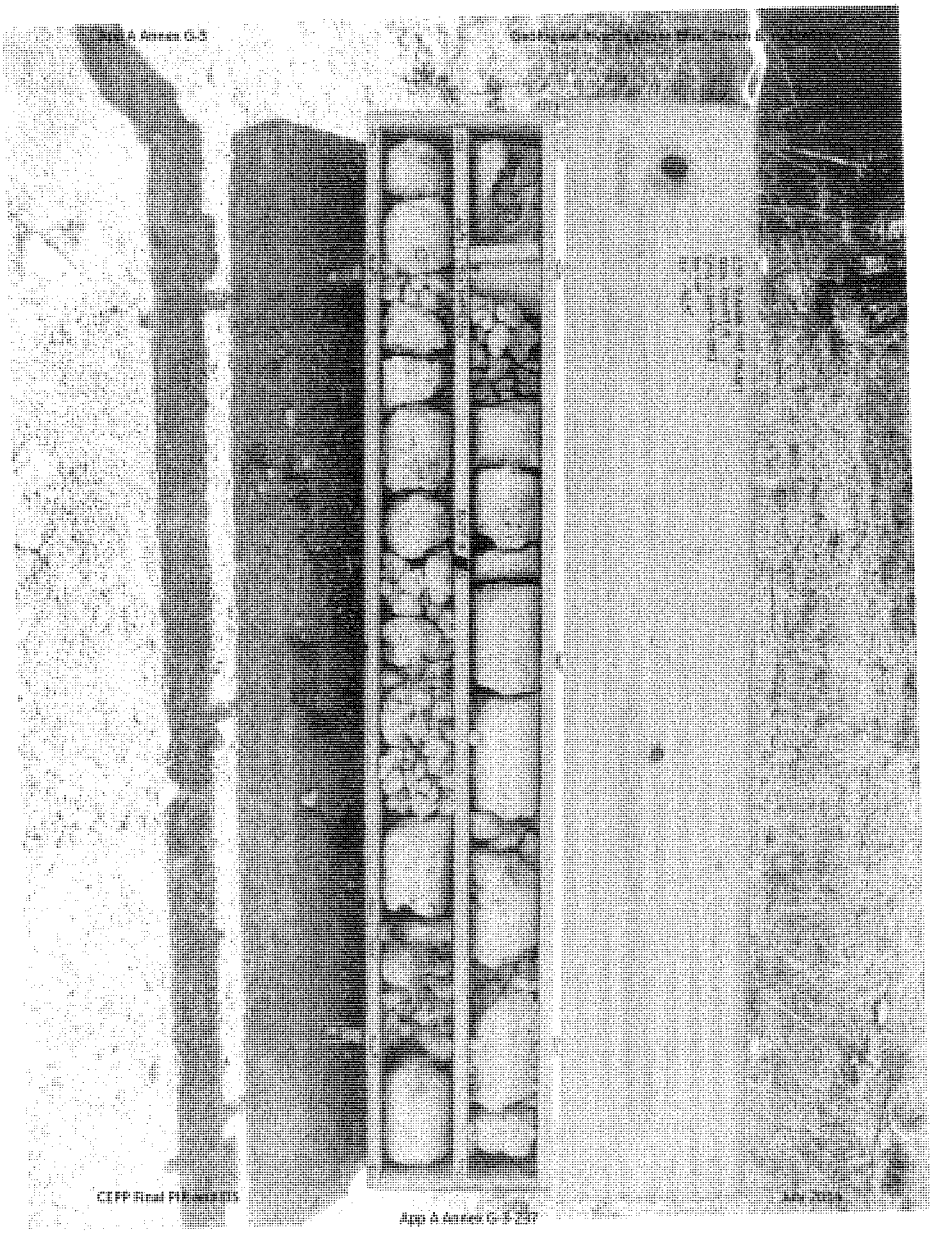


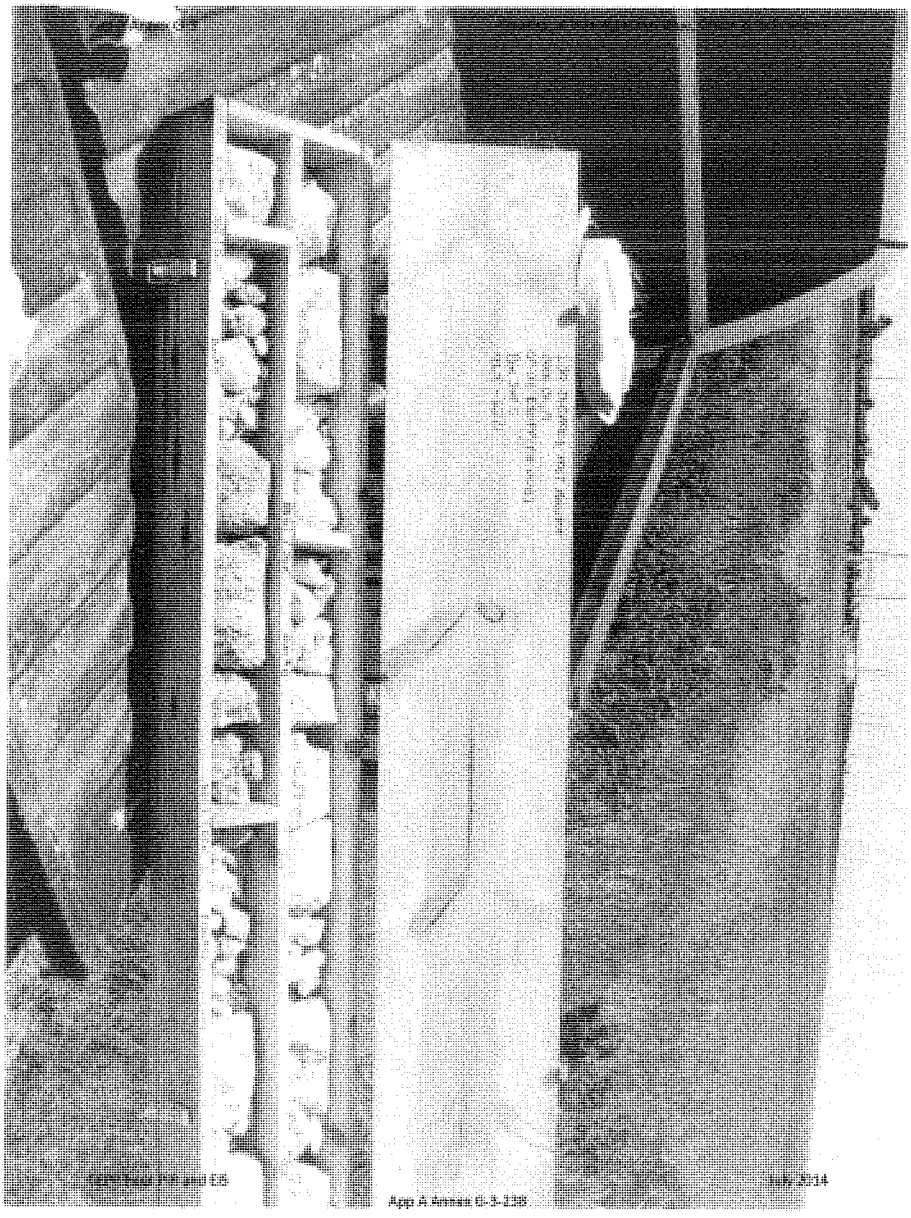


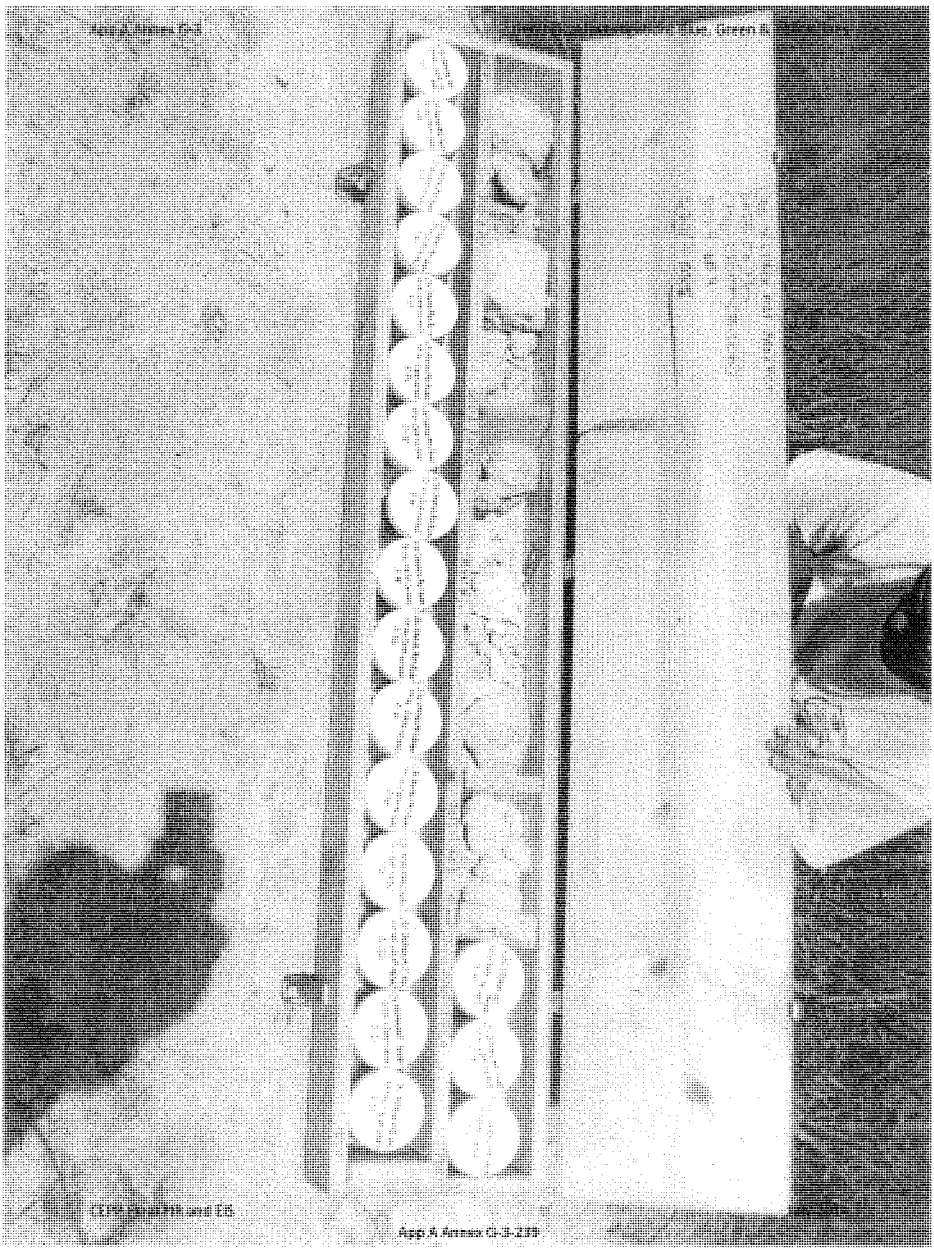




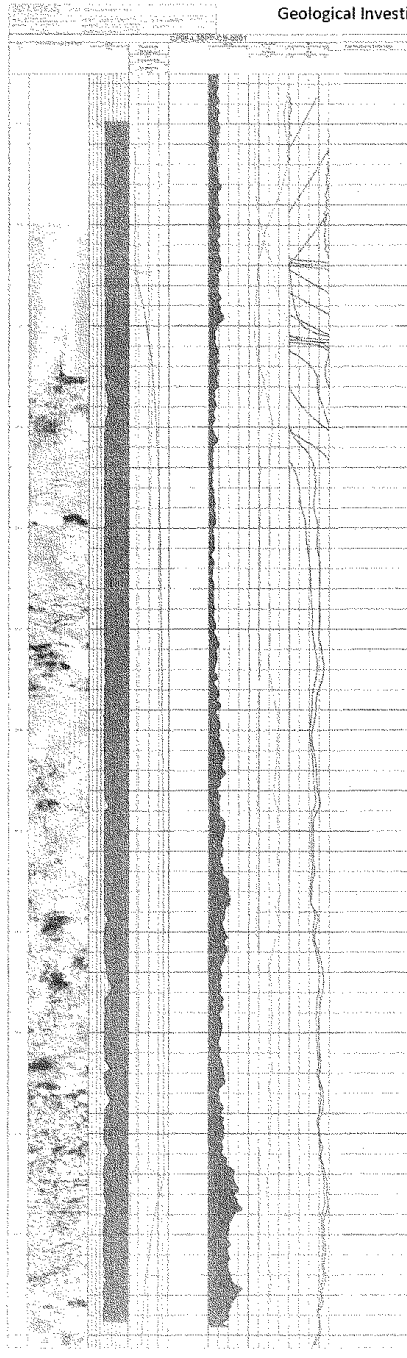








U.S.G.S. BOREHOLE LOGS



Well	Aquifer	Direction	Distance from Kerbinooka Road (m) (with bore number)	Percent Recovery	Aquifer or Water Source	Sample Collection Date	Sample Collection Time	Uranium (mg/L)	Gross Alpha Activity (Bq/L)	Gross Alpha Reporting Level (Bq/L)	WQ PI Alpha (Bq/L)
MW 100 upper	Recharge		7.772040		UFA	12-Jul-11	12:06				
OKF-100 lower	Recharge		7.772040		APF2	12-Jul-11	12:06				
EKKR-1	Recharge		2.639602		Surface Water	11-Jul-11	15:25	0.097	3	U	
MW-18	Recharge	Week 1			UFA - 4200 FT						
MW-19	Recharge				UFA - 2350 FT						
MW-10	Recharge		7.772040		UFA - 350 ft SDMW	13-Jul-11	9:00				
MW-17	Recharge				SAS						
OKF-100 upper	Recharge		51.776135		UFA	17-Jul-11	11:40	4.07	3	U	
OKF-100 lower	Recharge		51.776135		APF2	27-Jul-11	12:54	2.26	3	U	
EKKR-1	Recharge		51.776135		Surface Water	26-Jul-11	13:10	0.248	3	U	
MW-18	Recharge	Week 3	51.776274		UFA - 4200 FT	28-Jul-11	11:17				
MW-19	Recharge		58.776274		UFA - 2350 FT	26-Jul-11	13:35				
MW-10	Recharge		58.776274		UFA - 350 ft SDMW	28-Jul-11	15:05	1.43			
MW-17	Recharge				SAS	28-Jul-11	09:05				
OKF-100 upper	Recharge		144.575563		UFA	2-Aug-11	8:21	3.15	3	U	
OKF-100 lower	Recharge		144.575563		APF2	9-Aug-11	11:07				
EKKR-1	Recharge		149.727474		Surface Water	10-Aug-11	11:50	1.11	3	U	
MW-18	Recharge	Week 5			UFA - 4200 FT						
MW-19	Recharge				UFA - 2350 FT						
MW-10	Recharge		149.727474		UFA - 350 ft SDMW	10-Aug-11	12:50	0.252	3	U	
MW-17	Recharge				SAS						
OKF-100 upper	Recharge		214.205367		UFA	23-Aug-11	11:50	2.95	3	U	
OKF-100 lower	Recharge		214.205367		APF2	23-Aug-11	12:00	3.38	3	U	
EKKR-1	Recharge		219.290581		Surface Water	24-Aug-11	11:30	0.845	3	U	
MW-18	Recharge	Week 7	224.014730		UFA - 4200 FT	25-Aug-11	12:02				
MW-19	Recharge		224.014730		UFA - 2350 FT	26-Aug-11	09:32				
MW-10	Recharge		224.014730		UFA - 350 ft SDMW	26-Aug-11	10:45	1.23	3	U	
MW-17	Recharge				SAS	24-Aug-11	12:30	2.62	3	U	
OKF-100 upper	Recharge		284.282110		UFA	7-Sep-11	11:50	4.06	3	U	
OKF-100 lower	Recharge		284.282110		APF2	1-Sep-11	12:40	5.18	3	U	
EKKR-1	Recharge		284.491300		Surface Water	6-Sep-11	11:10	0.421	3	U	
MW-18	Recharge	Week 9	304.1366264		UFA - 4200 FT	8-Sep-11	13:05				
MW-19	Recharge		304.1366264		UFA - 2350 FT	8-Sep-11	14:02				
MW-10	Recharge		304.1366264		UFA - 350 ft SDMW	8-Sep-11	15:40				
MW-17	Recharge				SAS	6-Sep-11	12:23	6.16	3	U	
OKF-100 upper	Recharge		433.561124		UFA	5-Oct-11	12:50	2.82	3	U	
OKF-100 lower	Recharge		433.561124		APF2	5-Oct-11	13:30	2.58	3	U	
EKKR-1	Recharge		429.548563		Surface Water	4-Oct-11	11:30	0.281	3	U	
MW-18	Recharge	Week 13	438.5825563		UFA - 4200 FT	6-Oct-11	12:20				
MW-19	Recharge		438.582562		UFA - 2350 FT	6-Oct-11	14:07				
MW-10	Recharge		438.582562		UFA - 350 ft SDMW	6-Oct-11	11:00	2.70	3	U	
MW-17	Recharge				SAS	4-Oct-11	12:45	0.97	3	U	
OKF-100 upper	Recharge		536.643012		UFA	2-Nov-11	12:35	1.44	3	U	
OKF-100 lower	Recharge		541.864719		APF2	3-Nov-11	11:17				
EKKR-1	Recharge		536.643012		Surface Water	2-Nov-11	10:35	0.0372	3	U	
MW-18	Recharge	Week 17	541.864719		UFA - 4200 FT	3-Nov-11	12:55				
MW-19	Recharge		541.864719		UFA - 2350 FT	3-Nov-11	13:42				
MW-10	Recharge		541.864719		UFA - 350 ft SDMW	3-Nov-11	16:05				
MW-17	Recharge				SAS	2-Nov-11	11:12	3.46	3	U	
OKF-100 upper	Recharge		713.819307		UFA	7-Dec-11	10:35	1.3	3	U	
OKF-100 lower	Recharge		713.819152		APF2	8-Dec-11	13:05				
EKKR-1	Recharge		713.819307		Surface Water	7-Dec-11	11:50	0.563	3	U	
MW-18	Recharge	Week 21	718.019152		UFA - 4200 FT	8-Dec-11	14:05	1.15	3	U	
MW-19	Recharge		718.019152		UFA - 2350 FT	8-Dec-11	15:11				
MW-10	Recharge		718.819152		UFA - 350 ft SDMW	8-Dec-11	11:30	0.696	3	U	
MW-17	Recharge				SAS	7-Dec-11	10:20	0.3	3	U	
OKF-100 upper	Recharge		847.980795		UFA	3-Jan-12	12:10	36	3	U	
OKF-100 lower	Recharge		847.980795		APF2	3-Jan-12	13:10	4.54	3	U	
EKKR-1	Recharge		852.953765		Surface Water	4-Jan-12	11:15	0.269	3	U	
MW-18	Recharge	Week 25	857.984459		UFA - 4200 FT	5-Jan-12	11:15				
MW-19	Recharge		857.984459		UFA - 2350 FT	5-Jan-12	10:25				
MW-10	Recharge		857.984459		UFA - 350 ft SDMW	5-Jan-12	13:20	0.837	3	U	
MW-17	Recharge				SAS	5-Jan-12	13:35	3.82	3	U	
OKF-100 upper	Storage		868.358723		UFA	8-Feb-12	11:35	1.08	3	U	
OKF-100 upper	Storage		868.358723		UFA	23-Feb-12	12:07				
OKF-100 lower	Recharge		868.358723		APF2	8-Feb-12	12:15	0.259	3	U	
EKKR-1	Recharge		868.358723		Surface Water	23-Feb-12	11:55	0.403	3	U	
EKKR-10	Recharge	Week 29-31	868.358723		Surface Water	3-Feb-12	11:50				
MW-19	Recharge		868.358723		UFA - 4200 FT	9-Feb-12	12:02				
MW-18	Recharge		868.358723		UFA - 2350 FT	9-Feb-12	10:10				
MW-10	Recharge		868.2505723		UFA - 350 ft SDMW	8-Feb-12	10:40	0.0478	3	U	
MW-15	Recharge		868.358723		UFA - 2350 ft SDMW	23-Feb-12	11:20	0.0478	3	U	
MW-17	Recharge				SAS	9-Feb-12	12:05	2.67	3	U	
OKF-100 upper	Storage		868.358723		UFA	8-Mar-12	12:00	0.96	3	U	
OKF-100 upper	Storage		868.358723		UFA	5-Mar-12	13:45	5.22	3	U	
EKKR-1	Storage		868.358723		Stored Water						
MW-10	Storage	Weeks 32-34	868.358723		UFA - 350 ft SDMW	8-Mar-12	09:17				
MW-19	Storage		868.358723		UFA - 2350 FT	5-Mar-12	12:45				
MW-10	Storage		868.358723		UFA - 350 ft SDMW	5-Mar-12	11:15	0.0545	3	U	
MW-17	Storage				SAS	5-Mar-12	12:05	2.72	3	U	
OKF-100 upper	Storage		868.358723		UFA	29-Mar-12	11:50				
OKF-100 upper	Storage		868.358723		UFA	5-Apr-12	10:00	1.23	3	U	
OKF-100 lower	Storage		868.358723		APF2	5-Apr-12	11:30	0.941	3	U	
EKKR-1	Storage	Weeks 35-37	868.358723		Stored Water						
MW-19	Storage		868.358723		UFA - 4200 FT	2-Apr-12	11:00				
MW-18	Storage		868.358723		UFA - 2350 FT	3-Apr-12	10:05				
MW-10	Storage		868.358723		UFA - 350 ft SDMW	3-Apr-12	10:30	0.0	3	U	
MW-17	Storage				SAS	5-Apr-12	12:05	1.61	3	U	
OKF-100 upper	Storage		868.358723		UFA	10-Apr-12	11:05				
OKF-100 upper	Storage		868.358723		UFA	4-Apr-12	10:05	1.53	3	U	
OKF-100 lower	Storage		868.358723		APF2	4-Apr-12	11:00	0.901	3	U	
EKKR-1	Storage		868.358723		Stored Water						
EKKR-10	Storage	Week 38-40	868.358723		UFA - 4200 FT	9-Apr-12	11:03				
MW-18	Storage		868.358723		UFA - 2350 FT	9-Apr-12	10:40				
MW-19	Storage		868.358723		UFA - 350 ft SDMW	9-Apr-12	10:25	0.0	3	U	
MW-17	Storage				SAS	9-Apr-12	12:05	1.35	3	U	
OKF-100 upper	Storage		868.358723		UFA	20-Apr-12	11:25	1.05	3	U	
OKF-100 upper	Storage		868.358723		UFA	24-Apr-12	12:37	1.04	3	U	
EKKR-1	Storage		868.358723		Stored Water						
MW-10	Storage	Week 41	868.358723		UFA - 4200 FT	3-May-12	11:14				
MW-19	Storage		868.358723		UFA - 2350 FT	3-May-12	10:23				
MW-10	Storage		868.358723		UFA - 350 ft SDMW	3-May-12	11:30	0.592	3	U	
MW-17	Storage				SAS	3-May-12	11:50	1.61	3	U	

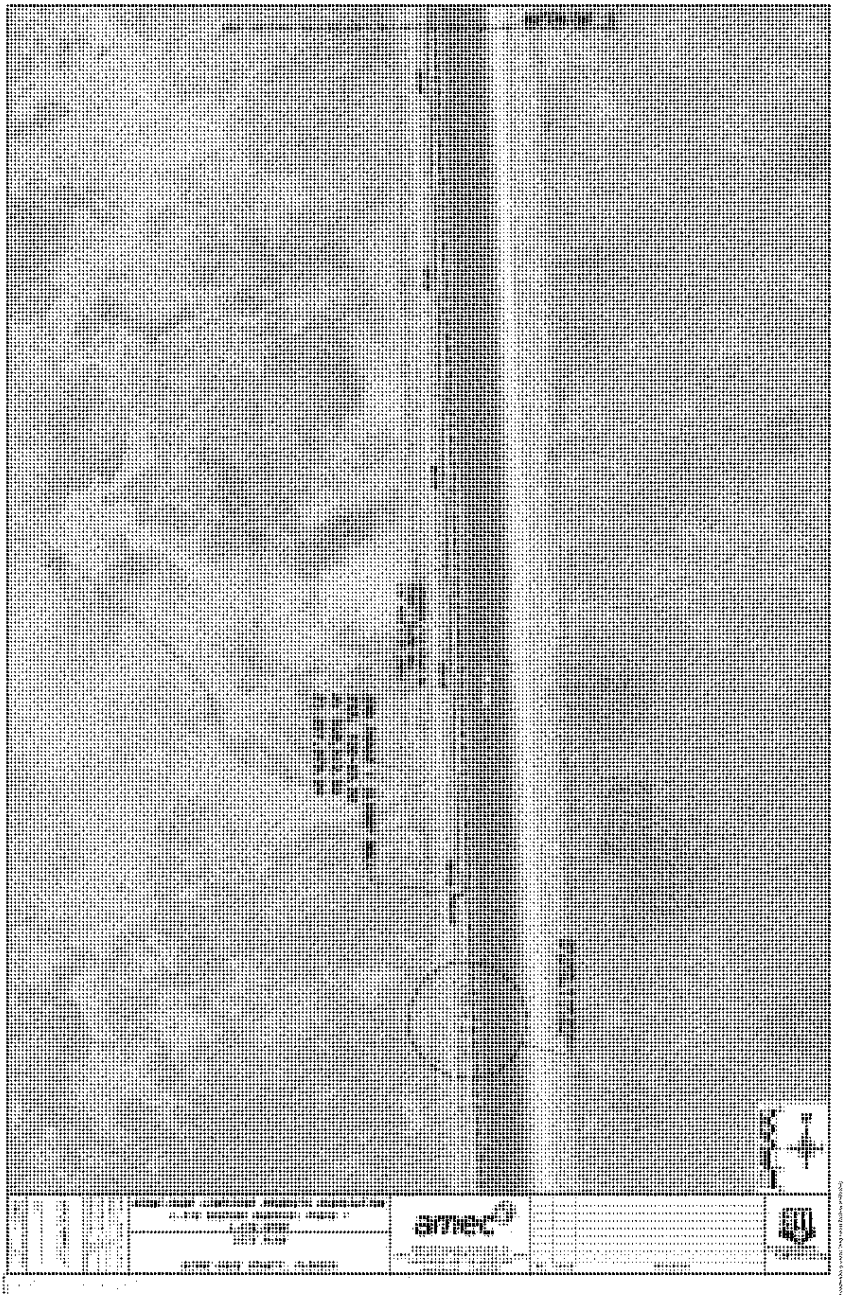
Well	Phase	Operation	Volume Recharged/Recovered based on meter (gallons)	Percent Recovery	Aquifer or Stored Source	Sample Collection Date	Sample Collection Time	Arsenic Concentration (µg/L)	Arsenic Speciation Completed	Arsenic Speciation Reported	VOC in LAB for any 524
CKP-100 upper	Storage	Week 48	998,358723		UFA	13-Nov-12	10:51	1.60			
CKP-100 lower	Storage		998,358724		APPZ	13-Nov-12	11:07	1.52			
EKKR-1	Storage		998,358725		Stored Water						
MW-18	Storage		998,358726		UFA - 4200 FT	13-Nov-12	13:31				
MW-19	Storage		998,358727		UFA - 3350 FT	14-Nov-12	14:18				
MW-10	Storage		998,358728		UFA - 350 ft SZMW	14-Nov-12	10:48	2.898	3	U	
MW-17	Storage				SAS	14-Nov-12	12:42	<2.71	3	U	
CKP-100 upper	Storage	Week 49	998,358729		UFA	17-Nov-12	10:57	1.96	3	U	
CKP-100 lower	Storage		998,358730		APPZ	17-Nov-12	11:07	<2.22	3	U	
EKKR-1	Storage		998,358731		Stored Water						
MW-18	Storage		998,358732		UFA - 4200 FT	17-Nov-12	12:31				
MW-19	Storage		998,358733		UFA - 3350 FT	17-Nov-12	14:46				
MW-10	Storage		998,358734		UFA - 350 ft SZMW	17-Nov-12	11:05	2.893	3	U	
MW-17	Storage				SAS	17-Nov-12	13:08	< 1.88	3	U	
CKP-100 upper	Storage	Week 50	998,358735		UFA	8-Aug-12	11:03	1.64	3	U	
CKP-100 lower	Storage		998,358736		APPZ	8-Aug-12	13:56	9.74	3	U	
EKKR-1	Storage		998,358737		Stored Water						
MW-09	Storage		998,358738		UFA - 4200 FT	8-Aug-12	12:13				
MW-18	Storage		998,358739		UFA - 3350 FT	8-Aug-12	13:20				
MW-10	Storage		998,358740		UFA - 350 ft SZMW	8-Aug-12	10:35	2.895	3	U	
MW-17	Storage				SAS	8-Aug-12	13:41	15.2	3	U	
CKP-100 upper	Storage	Week 51	998,358741		UFA	11-Sep-12	11:20	1.56	3	U	
CKP-100 lower	Storage		998,358742		APPZ	11-Sep-12	12:28	13.7	3	U	
EKKR-1	Storage		998,358743		Stored Water						
MW-19	Storage		998,358744		UFA - 4200 FT	12-Sep-12	12:11				
MW-18	Storage		998,358745		UFA - 3350 FT	12-Sep-12	13:36				
MW-10	Storage		998,358746		UFA - 350 ft SZMW	12-Sep-12	10:50	1.64	3	U	
MW-17	Storage				SAS	11-Sep-12	13:59	5.36	3	U	
CKP-100 upper	Storage	Week 52	998,358747		UFA	10-Oct-12	12:48	2.28	3	U	
CKP-100 lower	Storage		998,358748		APPZ	10-Oct-12	13:10	2.72	3	U	
EKKR-1	Storage		998,358749		Stored Water						
MW-19	Storage		998,358750		UFA - 4200 FT	10-Oct-12	14:07				
MW-18	Storage		998,358751		UFA - 3350 FT	11-Oct-12	11:45				
MW-10	Storage		998,358752		UFA - 350 ft SZMW	11-Oct-12	10:05	1.73	3	U	
MW-17	Storage				SAS	11-Oct-12	12:50	< 4.18	3	U	
CKP-100 upper	Storage	Week 53	998,358753		UFA	6-Nov-12	12:45	1.5	3	U	
CKP-100 lower	Storage		998,358754		APPZ	6-Nov-12	14:05	1.5	3	U	
EKKR-1	Storage		998,358755		Stored Water						
MW-19	Storage		998,358756		UFA - 4200 FT	6-Nov-12	13:12				
MW-18	Storage		998,358757		UFA - 3350 FT	6-Nov-12	13:47				
MW-10	Storage		998,358758		UFA - 350 ft SZMW	6-Nov-12	12:00	2.44	3	U	
MW-17	Storage				SAS	7-Nov-12	14:23	5	3	U	
CKP-100 upper	Storage	Week 54	998,358759		UFA	18-Dec-12	11:20	1.52	3	U	
CKP-100 lower	Storage		998,358760		APPZ	18-Dec-12	12:40	8.07	3	U	
EKKR-1	Storage		998,358761		Stored Water						
MW-19	Storage		998,358762		UFA - 4200 FT	20-Dec-12	10:47				
MW-18	Storage		998,358763		UFA - 3350 FT	20-Dec-12	12:27				
MW-10	Storage		998,358764		UFA - 350 ft SZMW	19-Dec-12	10:15	1.95	3	U	
MW-17	Storage				SAS	19-Dec-12	13:05	1.89	3	U	

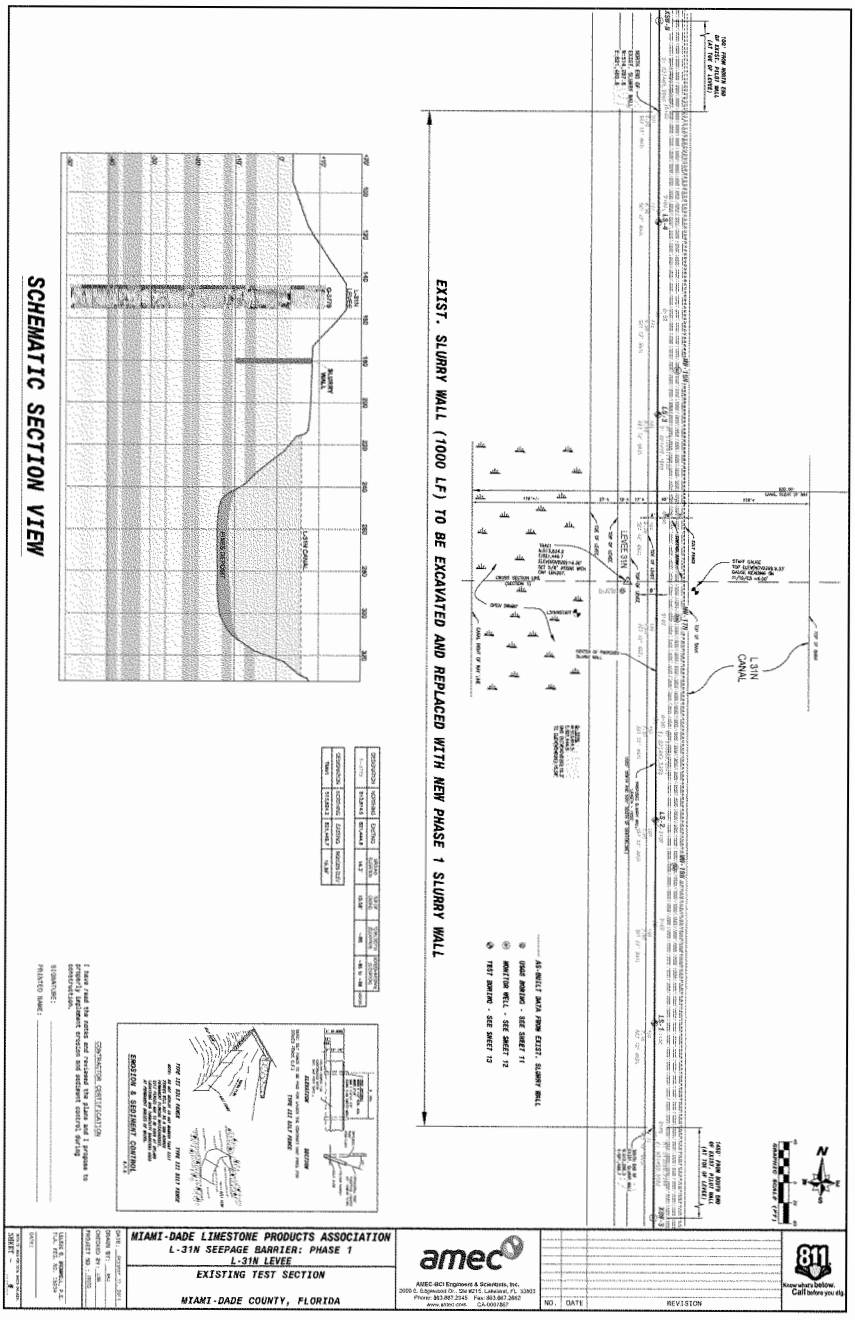
Table 8. Perchlorate concentrations and activities obtained during Cycle 4

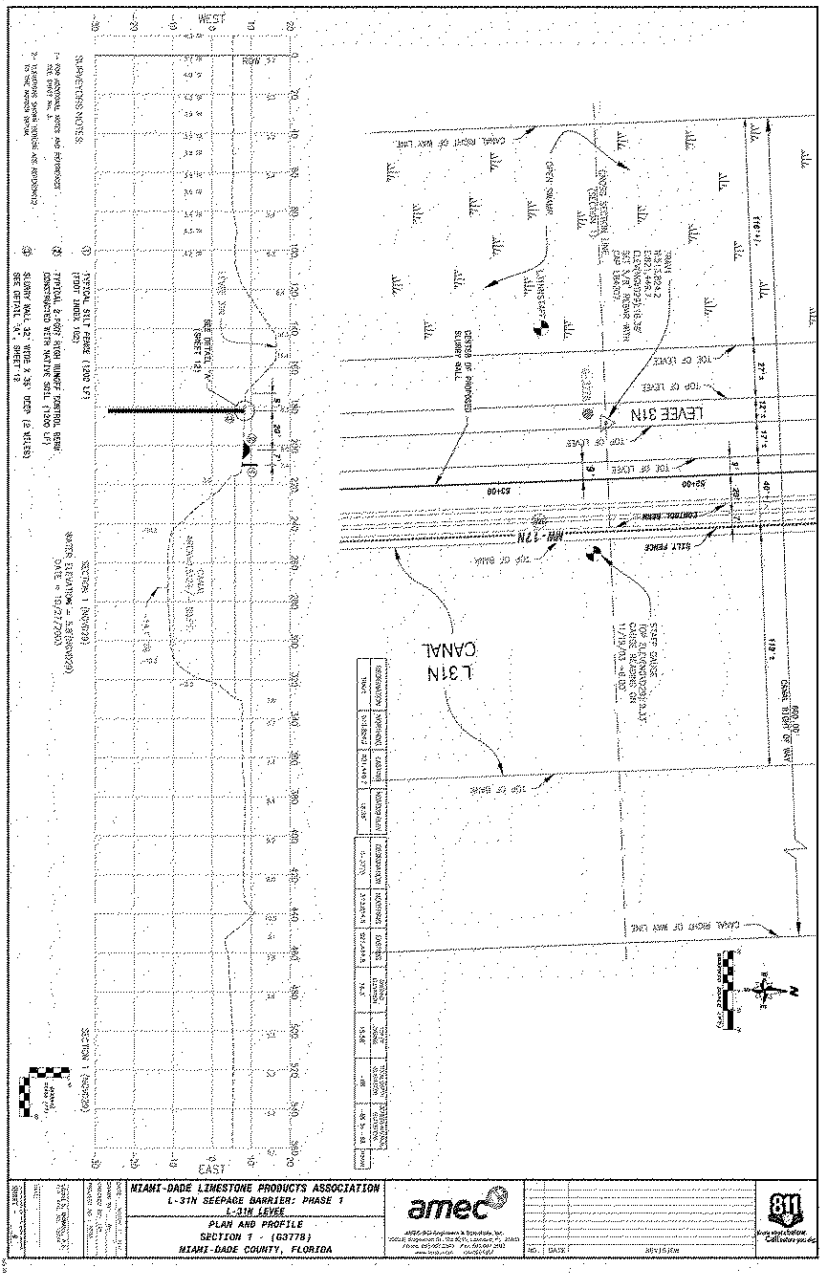
GEOLOGICAL INVESTIGATION PERTAINING TO L31N SLURRY WALL CONSTRUCTION

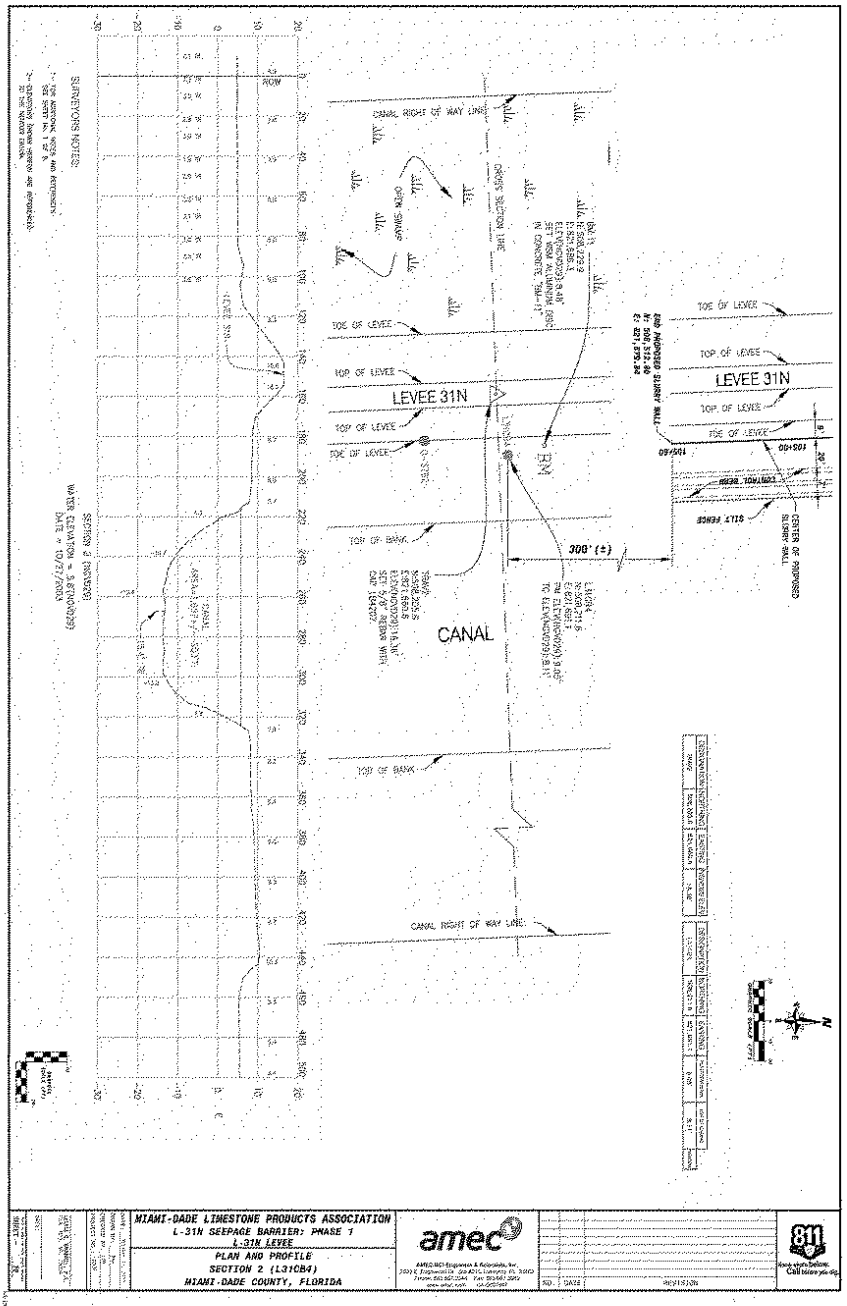
(U.S. ARMY CORPS OF ENGINEERS, 2011)

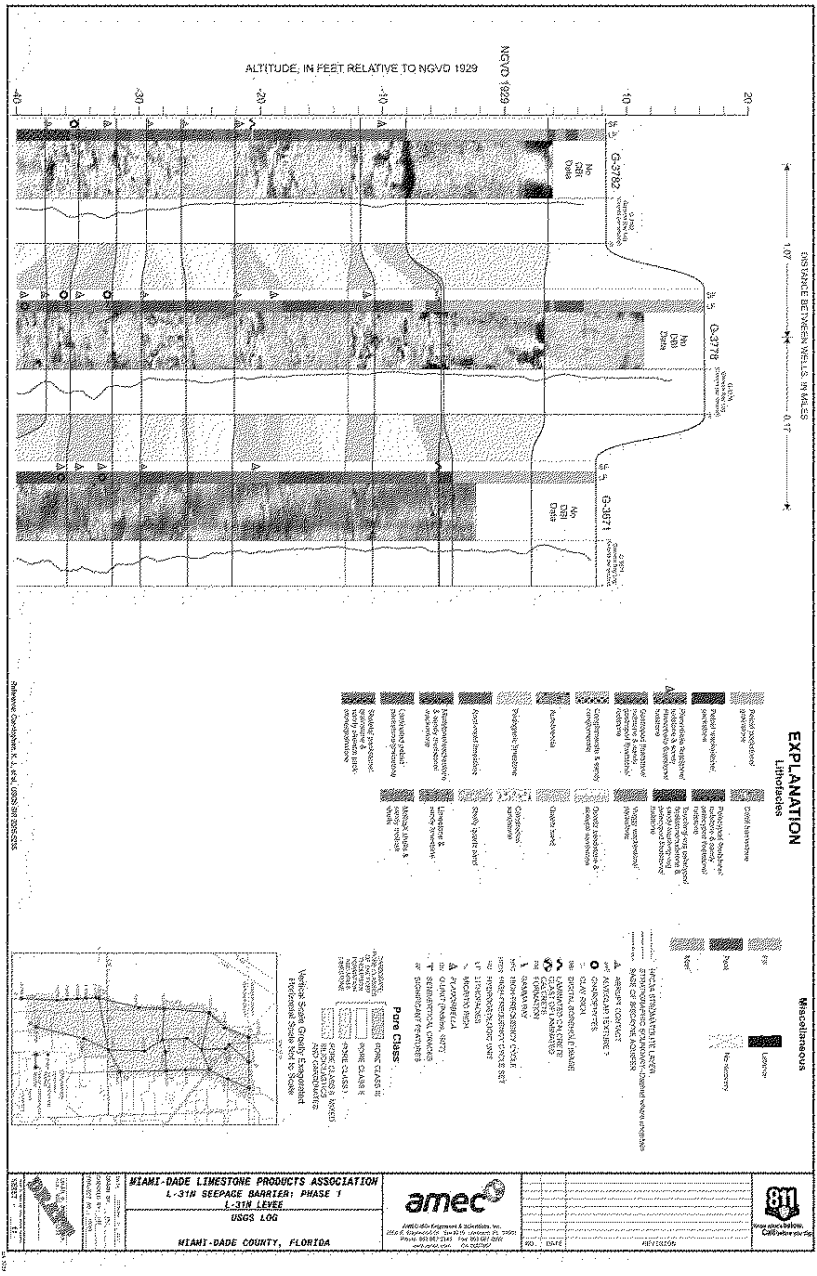


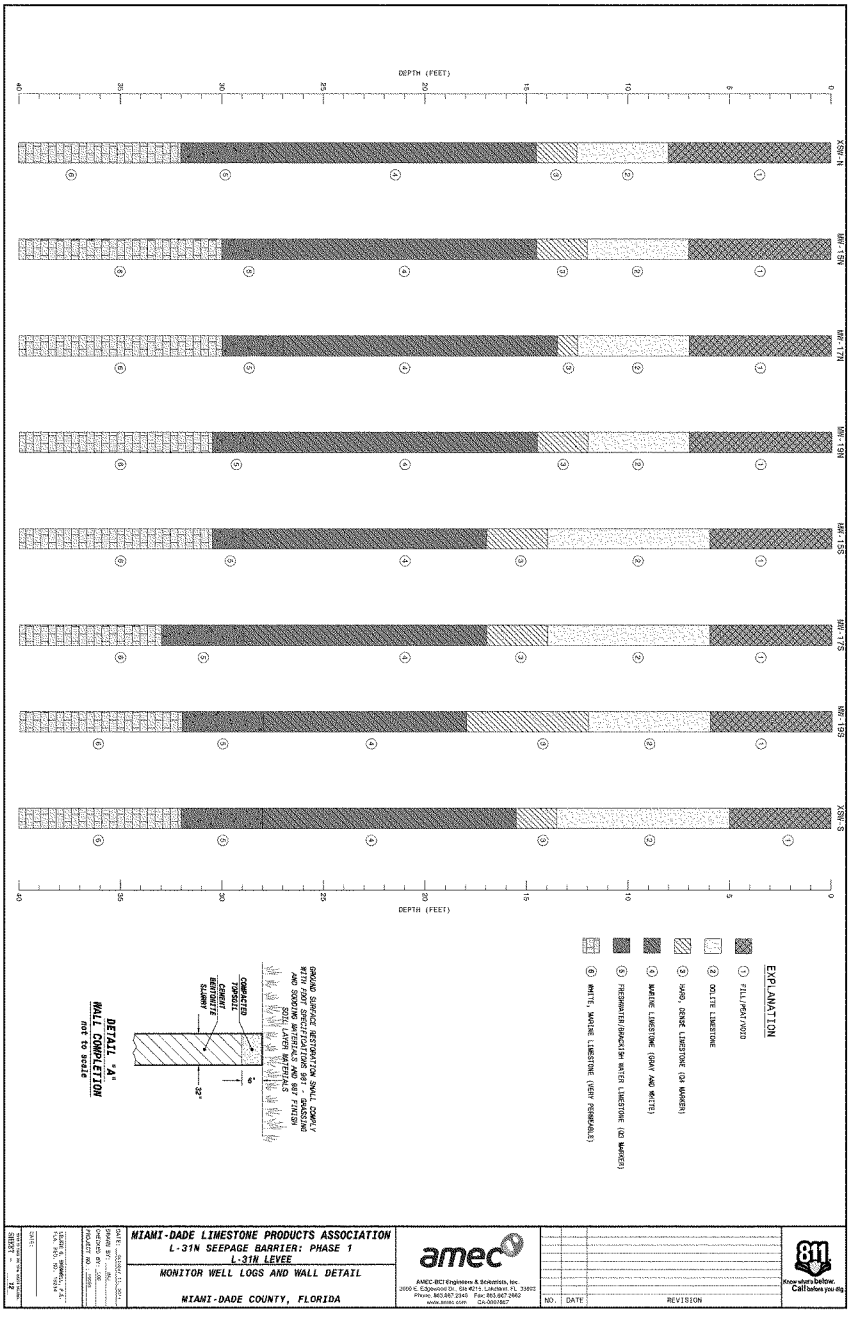


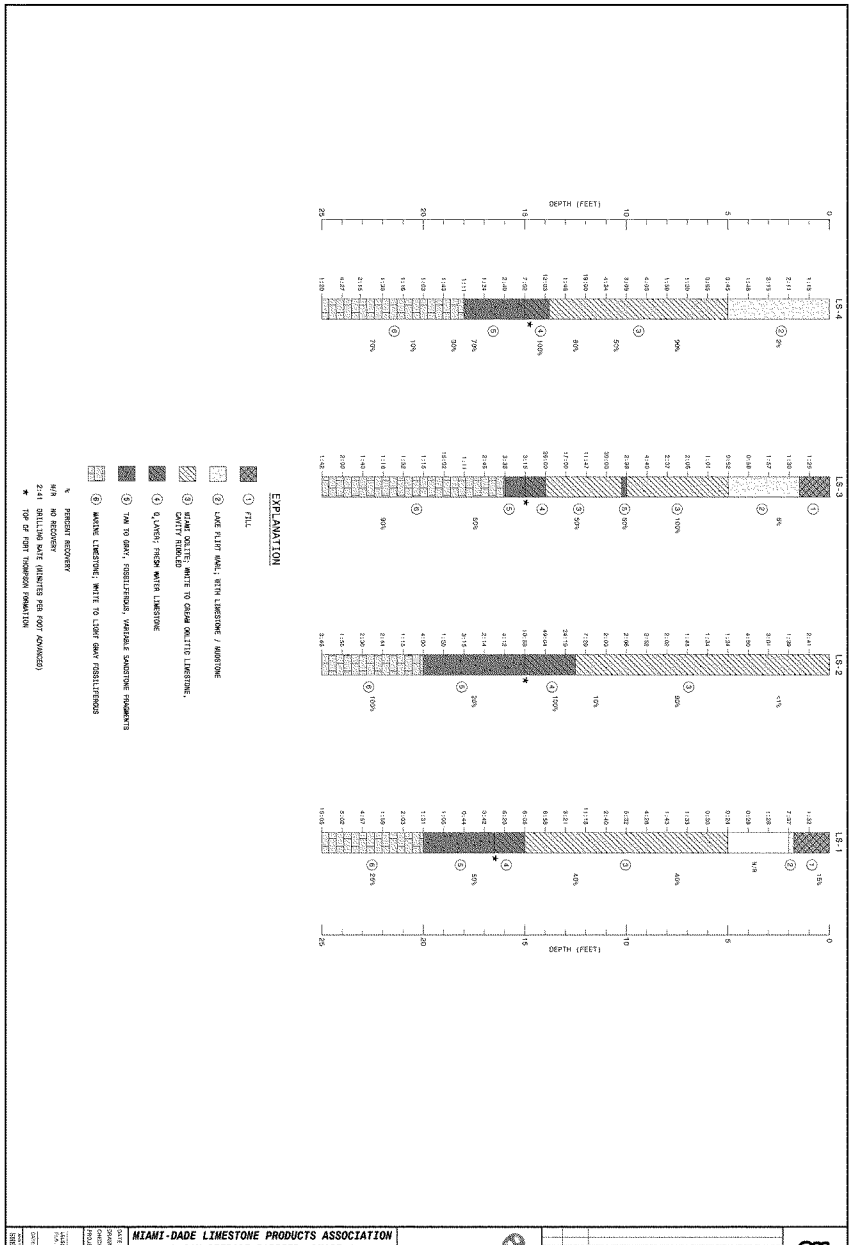

EXIST. SLURRY WALL (1000 LF) TO BE EXCAVATED AND REPLACED WITH NEW PHASE 1 SLURRY WALL
SCHEMATIC SECTION VIEW
L-31N CANAL
LEVEE 31N
MIAMI-DADE LIMESTONE PRODUCTS ASSOCIATION
L-31N SEEPAGE BARRIER: PHASE 1
L-31N LEVEE
EXISTING TEST SECTION
MIAMI-DADE COUNTY, FLORIDA
amec
REVISION
Know what's below. Call before you dig


MIAMI-DADE LIMESTONE PRODUCTS ASSOCIATION
L-31N SEEPAGE BARRIER: PHASE 1
L-31N LEVEE
PLAN AND PROFILE
SECTION 7 - (G377B)
MIAMI-DADE COUNTY, FLORIDA
amec
L31N CANAL
LEVEE 31N
MW-12N
SOIL CEMENT BARRIER WALL
CONTROL BASIN
SILT FENCE
TOP OF BANK
TOP OF LEVEE
TOE OF LEVEE
CANAL RIGHT OF WAY LINE
WEST
EAST
SECTION 7 (G377B)
SECTION 6 (G377A)
SECTION 18 (G378A)
SECTION 1 (G378B)
STATION 82+00
STATION 92+00
STATION 102+00
STATION 112+00
STATION 122+00
STATION 132+00
STATION 142+00
STATION 152+00
STATION 162+00
STATION 172+00
STATION 182+00
STATION 192+00
STATION 202+00
STATION 212+00
STATION 222+00
STATION 232+00
STATION 242+00
STATION 252+00
STATION 262+00
STATION 272+00
STATION


LEVEE 31N
TOP OF LEVEE
TOE OF LEVEE
TOP OF BANK
CANAL
CANAL RIGHT OF WAY LINE
300'(±)
MIAMI-DADE LIMESTONE PRODUCTS ASSOCIATION
L-31N SEEPAGE BARRIER: PHASE 1
L-31N LEVEE
PLAN AND PROFILE
SECTION 2 (L31CB4)
MIAMI-DADE COUNTY, FLORIDA


ALTITUDE, IN FEET RELATIVE TO NGVD 1929
NGVD 1929
-40
-30
-20
-10
0
10
20
DISTANCE BETWEEN WELLS, IN MILES
1.07
0.17
G-3782
G-3778
G-3674
Mx DBI Data
EXPLANATION
Lithofacies
Miscellaneous
Fill
Limerock
Peat
No recovery
Water
Pore Class
MIAMI-DADE LIMESTONE PRODUCTS ASSOCIATION
L-31N SEEPAGE BARRIER: PHASE 1
L-31N LEVEE
USGS LOG
MIAMI-DADE COUNTY, FLORIDA
amec
811
Know what's below. Call before you dig.


DEPTH (FEET)
MW-159N
MW-158N
MW-157N
MW-156N
MW-155S
MW-157S
MW-159S
XSW-S
EXPLANATION
1 FILL/MIXED/VOID
2 OOLITE LIMESTONE
3 HARD, DENSE LIMESTONE (NO MARKER)
4 MARINE LIMESTONE (GRAY AND WHITE)
5 FRESHWATER/BRACKISH WATER LIMESTONE (NO MARKER)
6 WHITE, MARINE LIMESTONE (VERY PERMEABLE)
GROUND SURFACE RESTORATION SHALL COMPLY WITH FDOT SPECIFICATIONS 981 - GRASSING AND SODDING WITH PERMANENT PLANTING SOIL, LATEX MATERIALS AT FINISH
COMPACTED TOPSOIL
CEMENT BENTONITE SLURRY
6"
12"
DETAIL "A"
WALL COMPLETION
not to scale
MIAMI-DADE LIMESTONE PRODUCTS ASSOCIATION
L-31N SEEPAGE BARRIER: PHASE 1
L-31N LEVEE
MONITOR WELL LOGS AND WALL DETAIL
MIAMI-DADE COUNTY, FLORIDA
amec
AMEC-BCI Engineers & Scientists, Inc.
2000 E. Edgewood Dr., Ste 401 Lakeland FL 33803
Phone: 863.667.2345 Fax: 863.667.2662
www.amec.com CA-0007867
NO. DATE REVISION
Know what's below. Call before you dig.
SHEET 12


DEPTH (FEET)
25
20
15
10
5
0
LS-4
LS-3
LS-2
LS-1
EXPLANATION
① FILL
② LAKE FLIRT MARL; WITH LIMESTONE / MARLSTONE
③ MIAMI OOLITE; WHITE TO GRAY OOLITIC LIMESTONE, CAVITY RUBBLED
④ Q_LAKES; FRESH WATER LIMESTONE
⑤ TAN TO GRAY; FOSSILIFEROUS, VARIABLE SANDSTONE FRAGMENTS
⑥ MARINE LIMESTONE; WHITE TO LIGHT GRAY FOSSILIFEROUS
% PERCENT RECOVERY
W/R NO RECOVERY
2:14 DRILLING RATE (MINUTES PER FOOT (AVERAGED)
★ TOP OF FLINT HAMMOCK FORMATION
MIAMI-DADE LIMESTONE PRODUCTS ASSOCIATION
L-31N SEEPAGE BARRIER: PHASE 1
L-31N LEVEE
BORING LOGS AND WALL DETAIL
MIAMI-DADE COUNTY, FLORIDA
amec
AMEC E&I Engineers & Scientists, Inc.
2000 E. Edgewood Dr., Ste #215, Lakeland, FL 33803
Phone: 863.667.2345 Fax: 863.667.2662
www.amec.com CA-0000867
NO. DATE REVISION
811 Know what's below. Call before you dig.
DATE: 10/2012
DESIGN BY: JRV
DRAWN BY: JRV
CHECKED BY: JRV
PROJECT NO.: 3600
LICENSE NUMBER
JOHN R. WORRALL, P.E.
FLA. REG. NO. 19824
DATE:
SHEET 13

ANNEX G4. CEPP PIR FLOW EASEMENT BASIN (FEB) PRELIMINARY SEEPAGE ANALYSIS

Geotechnical Seepage Analysis CEPP Flow Easement Basin (FEB)

1. General. This section is a description of the geotechnical seepage analysis performed for the Flow Equalization Basin (FEB) feature associated with the Central Everglades Protection Project (CEPP). The FEB is situated in South Florida and lies south of the Bolles Canal, north of Levee L-5, east of the Miami Canal (L-23) and west of the EAA project. It is to be bordered to the east by the STA3/4 Inflow Canal and to the South by the STA3/4 Supply Canal. The proposed FEB footprint is indicated in Figure G-1.

2. Regional Geology. The regional geologic conditions of the proposed FEB are varied in this area (see Figure G-1). Along the southern boundary near L-5, and the Miami Canal to the west, recent fill materials consisting of poorly graded gravel, sand, silt, and minor amounts of shells vary in thickness from 0.5 foot to 6 feet thick. This fill material extends to other canal areas of Broward County. Below this fill material and throughout most of the surficial cover of northern Broward County, Quaternary shelly-sediments of the Plio-Pleistocene age prevail. The shelly sediments consist of mollusk bearing sediments (sands and carbonates) (P. Schweitzer, 2010). These conditions may also be marginally applicable to the FEB site in Palm Beach County as well.

Below these sediments is the Miami Limestone (Pleistocene) which represents the upper portion of the well-known Biscayne Aquifer. Thickness of the Biscayne Aquifer varies considerably from 10 feet in the northwest end of the county to 240 feet by Ft. Lauderdale which is situated in eastern Broward County (U.S. Geological Survey, 1970); however, the Miami Limestone's maximum thickness is 40 feet toward the coast (U.S. Army of Corps of Engineers, 2011). The Miami Limestone consists of two facies (P. Schweitzer, 2010): an oolitic facies of white to orangish gray, poorly to moderately indurated, sandy, oolitic limestone with scattered concentrations of fossils and a bryozoan facies of white to orangish gray, poorly to well-indurated, sandy, fossiliferous limestone.

The Ft. Thompson Formation represents the base of the Biscayne Aquifer. It is over 200 feet thick in eastern Palm Beach County. This unit consists of alternating beds of marine, brackish and freshwater limestones. The hydraulic conductivity of this formation averages 40,000 feet per day (U.S. Army Corps of Engineers, 2011).

Groundwater within the Biscayne Aquifer is at or near the ground surface and is generally undulating conforming to the topography. The water table commonly slopes eastward toward the coast, except in the Everglades, where it slopes southward. The groundwater table normally lies within the Miami Limestone or organic soils of recent age. Water table fluctuations are heavily influenced by seasonal rainfall, natural discharge, and pumping.

3. Local Geology. The local geology of the FEB feature begins at the surface with peaty material (peaty clay and/or organic sand), generally with an average thickness of 5-8 feet. Below that are undifferentiated layers of sandy, clayey materials of marginal thickness. Below these are consolidated and unconsolidated sediments of the Ft. Thompson formation. The Ft. Thompson limestone is pitted to vuggy with quartz sand-filled voids. The thickness of the Ft. Thompson limestone in this area is indeterminable at this time due to sparse subsurface exploration data.

Underlying the Ft. Thompson formation is the Caloosahatchee Marl which consists of shelly sands and shell marls. Below this formation is the Tamiami Formation which has a maximum depth of 65 feet to the top of the formation. This is the base of the unconfined water-table aquifer (Schroeder et al, 1954). Within the FEB, the majority of the surficial soils are Histosols which includes Everglades peats and Loxahatchee peats (Gleason et al., 1974; Bruland, 2006). According to Gleason et al, 1974, Everglades peats develop on topographic high areas and are comprised of *Cladium* tissue. Everglades peats are typically brown to black with minimal mineral content. Loxahatchee peats are found in topographic low areas and are composed of the remains of the roots and rhizomes of *Nymphea*, a white water lily. Loxahatchee peats have been classified as the Terra Ceia series (Euic, hyperthermic Typic Haplosaprists) (Soil Conservation Service, 1978). The western margin of WCA-3A is mixed marl peats that are derived from the underlying limestone (Brown et al., 1991).

4. Seismicity. South Florida is considered to be one of the most seismically stable locations in the United States (Petersen, Mark D. et. al, 2008). Historically, only minor shocks have occurred, with only one that resulted in damage. Additional shocks of suspect origin have been recorded that were felt in the Everglades area. The three Florida shocks of doubtful seismic origin rumbled through the Everglades, La Belle/Fort Myers area in July 1930, Tampa in December 1940, and the Miami/Everglades/Fort Myers area in January 1942. Most authorities attributed these incidents to blasting, but a few contend that they were seismic.

ER 1110-2-1806, (1995) indicates that South Florida is in Seismic Zone 0 (areas with least potential for seismic activity). Since no capable faults or recent earthquake epicenters are known to exist near the project site, the possibility of accelerations at the site approaching that required to induce liquefaction of the subsurface is remote. However, since this is a planned permanent impoundment and the underlying soils contain loose sand and silt granular material, a liquefaction screening evaluation will be conducted in accordance with CERP Design Criteria Memorandum No. 6. This screening will be conducted once the geotechnical investigations are completed.

5. Existing Project Data. There is only a sparse amount of subsurface geotechnical data available for the FEB. Existing subsurface used to develop the eastern dike seepage analysis cross section was taken from the EAA Reservoir A-1 Geotechnical Data Report of March 2006. A core boring and recharge test was also taken within the reservoir area with the core boring log CP02-EAARS-CB-0002 presented in Appendix G-1. This information was obtained from Report No. 02-042, Ardaman and Associates, 2003. To evaluate the seepage on the west side of the FEB, C & SF Part I Agricultural and Conservation Areas, Supplement 1 – Geology and Soils, December, 1951 provided geologic cross sections that provide subsurface information for the north and west sides of the proposed FEB impoundment. The western boundary subsurface profile can be approximately defined by Figure G-2 along L-23 from sta. 0+00 to sta. 600+00. The northern subsurface boundary of the FEB can be approximated by the cross sections taken along L -22 shown on Figures G-3 and G-4 from sta. 532+18 to sta. 0+00.

6. Seepage Model. The seepage analysis was performed on two sections of the proposed perimeter levee and canal system. The models consist of one typical section for the east dike and one of the west dike. A copy of the idealized geometry and water surface elevations used in the seepage analysis are shown on Figures G-5 and G-6. The computational tool used to model the seepage for the east and west cross sections was the two dimensional finite element program SEEP/W. The east and west SEEP/W representations of the input model are shown on Figures G-7 and G-8. Layers and hydraulic input parameters used in the SEEP/W cross sections are provided in Tables G-1 and G-2. The impoundment water level was kept at el. 10.0 ft with tailwater at the dike toe at elevation 6.0 ft.

The subsurface characterization for the model was conducted using an idealized geologic profile utilized for the EAA project immediately east of the project feature site. Due to the extremely limited geotechnical exploration data in the area of the FEB footprint, the modeled results presented provide only a tentative estimate of seepage quantities. The western cross section model was based on a recharge test at location RT-2 near core boring CP02-EAARS-CB-0002. This boring, which is located in the middle of the proposed reservoir, was performed in the 2003 geotechnical exploration program for the EAA and as described by Report No. 02-042, Ardaman and Associates, 2003. Other subsurface information used for development of the west section model was the C & SF Part I Agricultural and Conservation Areas, Supplement 1 – Geology and Soils, December, 1951 and C & SF Part I Agricultural and Conservation Areas, Supplement 7 – Permeability Investigations by Well Pumping Tests, February, 1953, and Report of Investigations No. 13 (RI-13), Water Resources of Palm Beach County, Florida, 1954.

Table G-1. Eastern Seepage Model Cross Section Material Properties

Layer	Elevation Extent (feet)	Kx, Horizontal Hydraulic Conductivity (fpd)	Anisotropy Ratio, Ky/Kx
Dike Sand	EL. 15.0->EL. 6.0	3.0	1.0
Caprock Limestone	EL. 6.0->EL.3.0	100	0.1
Upper Okeechobee-Upper Limestone	EL. 3.0-> -13.0	60	0.42
Upper Okeechobee-Lower Limestone	EL. -13.0 ->-24.0	200	0.375
Lower Okeechobee-Upper Sands	EL. -24.0 ->-56.2	250	0.5
Tamiami Formation	EL. -56.20 ->-89.9	36	0.5

Table G-2. Western Seepage Model Cross Section Material Properties

Layer	Elevation Extent (feet)	Kx, Horizontal Hydraulic Conductivity (fpd)	Anisotropy Ratio, Ky/Kx
Dike Sand	EL. 15.0->EL. 6.0	3.0	1.0
Caprock Limestone	EL. 6.0->EL.3.0	283	0.1
Upper Okeechobee-Upper Limestone	EL. 3.0-> -13.0	72	0.42
Upper Okeechobee-Lower Limestone	EL. -13.0 ->-24.0	200	0.375
Lower Okeechobee-Upper Sands	EL. -24.0 ->-56.2	250	0.5
Tamiami Formation	EL. -56.20 ->-89.9	36	0.5

The regional hydrogeologic features of the project feature area show the surficial aquifer of sand, shell and limestone tends to thicken from the western boundary at Hendry County to the eastern edge of Palm Beach County. However, from north to south, the surficial aquifer top limestone beds thicken somewhat from Lake Okeechobee to about five miles south where they become more uniform in thickness. Supplement 1 (1951) indicates the presence of cavities in the top layers of the limestone in selected borings from 1-3 feet in thickness. These, however, do not seem to be continuous, at least along the line of borings. These features may have a profound effect on the hydraulic conductivity of the subsurface strata on the west side of the reservoir. To compensate for this, the hydraulic conductivities for the east section model were increased by 20% to account for a roughly 5.2% increase in porosity over the strata matrix hydraulic conductivity values. The caprock permeability in the west section model was increased from 100 ft/day to 283 ft/day based on results of the recharge test of Report No. 02-042 (2003).

The resulting seepage quantity for the east section was 320 cubic feet/day/ft of levee, and for the west section the seepage quantity was 387 cubic feet/day/ft of levee.

7. Future Geotechnical Investigations. The seepage quantities presented for the FEB are tentative estimates. As they are a basis for the project estimate, the subsurface materials need to be characterized by a geotechnical exploration and laboratory testing program. There is a very real possibility that previous core borings did not pick up key flow channels within the underlying limerock layers and these could be so conducive to flow that they will control the seepage losses for the reservoir. In addition, laminar flow assumptions used in the Darcy's Law based models may not be applicable in some areas. Scaled test sections at the adjacent EAA project show that maintaining an operating reservoir head level over an extended period of time may be difficult without seepage control systems such as cutoff walls or reservoir bottom treatment. Furthermore, there is a potential for piping of embankment material if there are cavities and natural pipes in the levee foundation. A comprehensive geotechnical exploration program featuring components such as reservoir foundation clearing and mapping along with geophysical testing, full-scale pump testing

along with design stage core boring exploration and geotechnical laboratory testing will be required. It is recommended to begin planning for such investigations as expeditiously as possible.

8. Borrow Materials. Sands from the proposed existing borrow from the exterior canal can be used as dike fill material. Whether they can be used without processing of limestone rock fragments is to be determined. With removal of organic surficial soils, dike foundation bearing and tolerable settlement levels are anticipated.

REFERENCES

Ardaman and Associates, 2003. Report No. 02-042, Revised Conceptual Report of Geotechnical Exploration for CERP Everglades Agricultural Area Reservoirs, Phase 1, Effort 1, Task Order 1, U.S. Army Engineer District Jacksonville.

Black and Veatch, 2006, EAA Reservoir A-1 Preliminary Design Report, South Florida Water management District, West Palm, Florida.

Brown, R.B. et al., 1991, Soils *In* Myers, R.L. and Ewl, J.J. (ed.) Ecosystems of Florida: University of Central Florida Press, Orlando, FL.

Bruland, G.L. et al, 2006, Spatial Distribution of Soil Properties in Water Conservation Area 3 of the Everglades: Journal of Soil Science Society of America, v. 70, pp. 1662-1676.

_____1951, C & SF Part I Agricultural and Conservation Areas, Supplement 1 – Geology and Soils, U.S. Army Engineer District Jacksonville.

_____1953, C & SF Part I Agricultural and Conservation Areas, Supplement 7 – Permeability Investigations by Well Pumping Tests, U.S. Army Engineer District Jacksonville.

Leech, S, Harris, C., Arnold, T. Burns, A., 2005, Geotechnical Seismic Evaluation of CERP Dam Foundations, CERP Design Criteria Memorandum No. 6, U.S. Army Engineer District Jacksonville and the South Florida Water Management District.

_____, ER 1110-2-1806, 1995, Earthquake Design and Evaluation for Civil Works Projects, Department of the Army, Washington, D.C..

Gleason, P.J. et al, 1974, The environmental significance of Holocene sediments from the Everglades and saline tidal plains, p. 297-351 *In* Gleason, P.J. (ed.) Environments of South Florida, present, and past: Miami Geological Society, Coral Gables, FL.

Nodarse and Associates, 2000, Stormwater Treatment Area No. 3 and 4 East WCA-3A Hydropattern Restoration L-5 Canal, Boring Profiles.

Petersen, Mark D., et al, 2008, Documentation for the 2008 Update of the United States National Seismic Hazard Maps: U.S. Geological Survey Open-File Report 2008–1128, 61 p.

Schroeder, M., Milliken, D., and Love, S., 1954, Water Resources of Palm Beach County, Florida – Report of Investigations No. 13, Florida Geological Survey, Tallahassee, FL.

Schweitzer, P., 2010, Mineral Resources On-Line Spatial Data, Geologic Units in Broward County, Florida: U.S. Geological Survey, 2 pp.

Soil Conversation Service, 1978, Soil Survey of Palm Beach County area of Florida: U.S. Government Printing Office, Washington D.C.

U.S. Army Corps of Engineers, 1954, Central and Southern Florida Project, Supplement 21 Design Memorandum Agricultural Area Levees L-4, L-5, and L-6, 72 pp.

U.S. Army Corps of Engineers, 2011, Central and Southern Florida Project, CERP, Biscayne Bay Coastal Wetlands Project Phase I, Final Integrated Project Implementation Report and Environmental Impact Statement, 512 pp.

U.S. Geological Survey, 1970, Groundwater Atlas of the United States, Alabama, Florida, Georgia, and South Carolina HA730-G.



Figure G-1. Aerial Photograph of Project Site

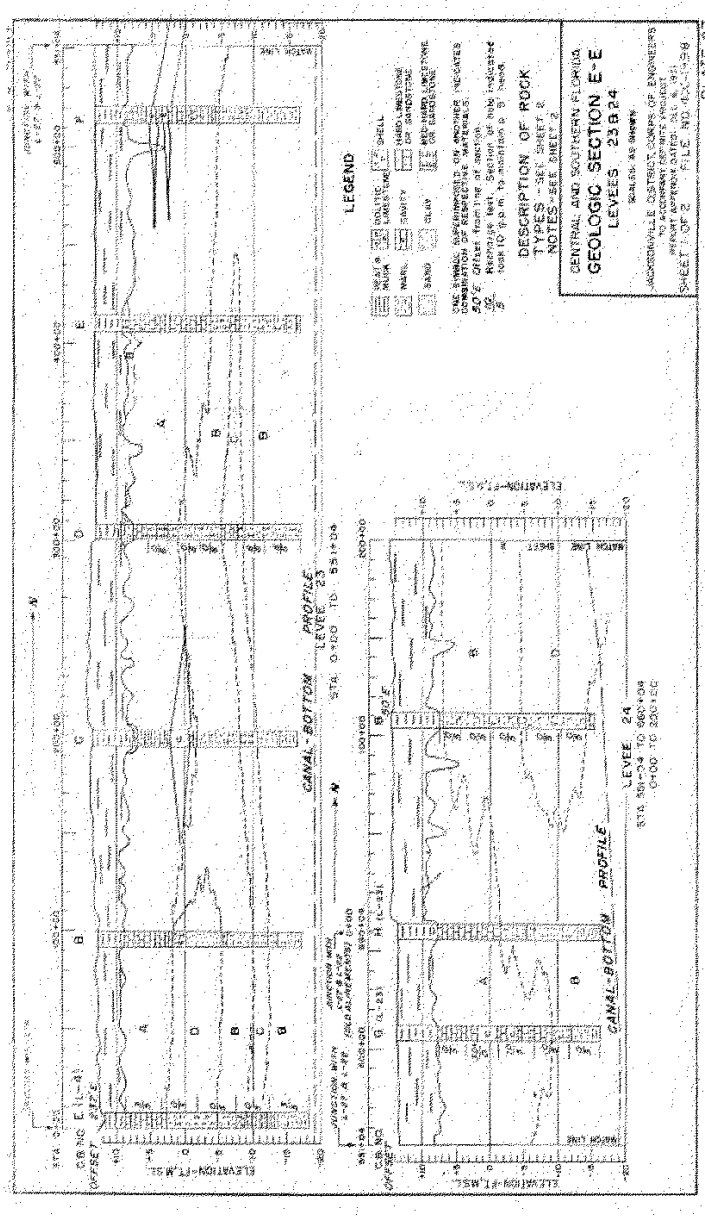


Figure G-2. Geologic Section L-23 & L-24

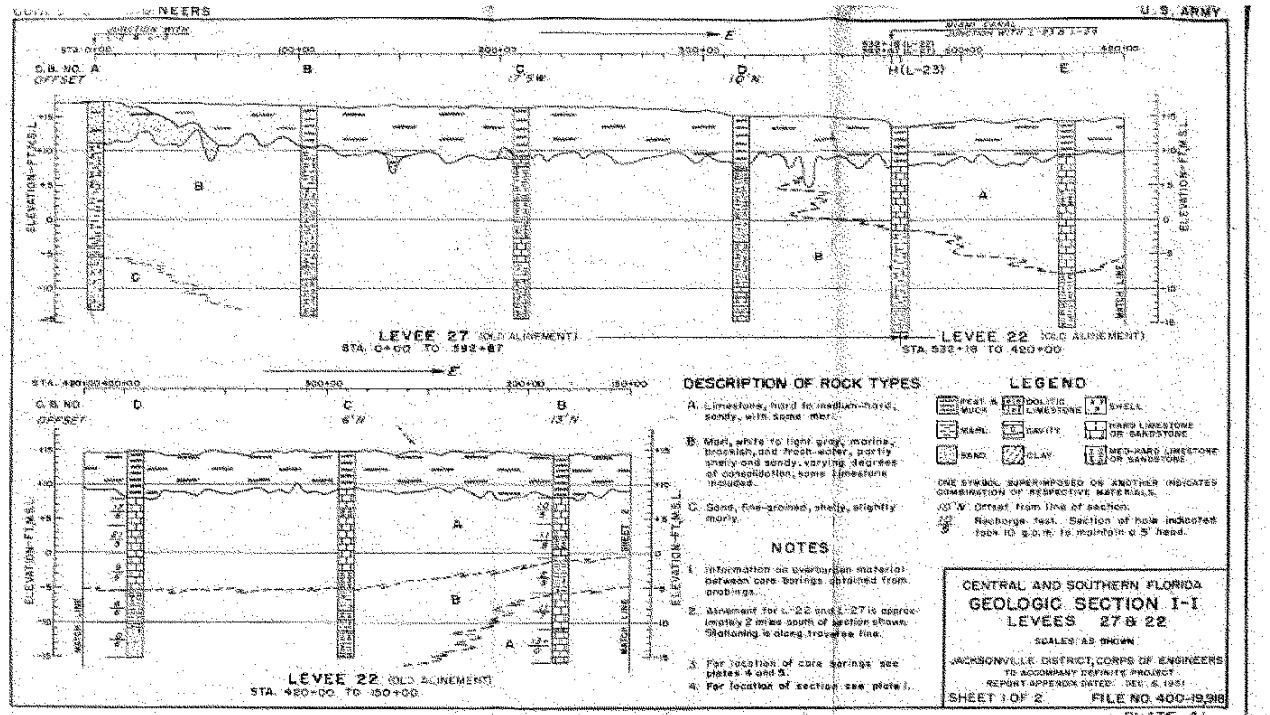


Figure G-3. Geologic Section L-27 & L-22

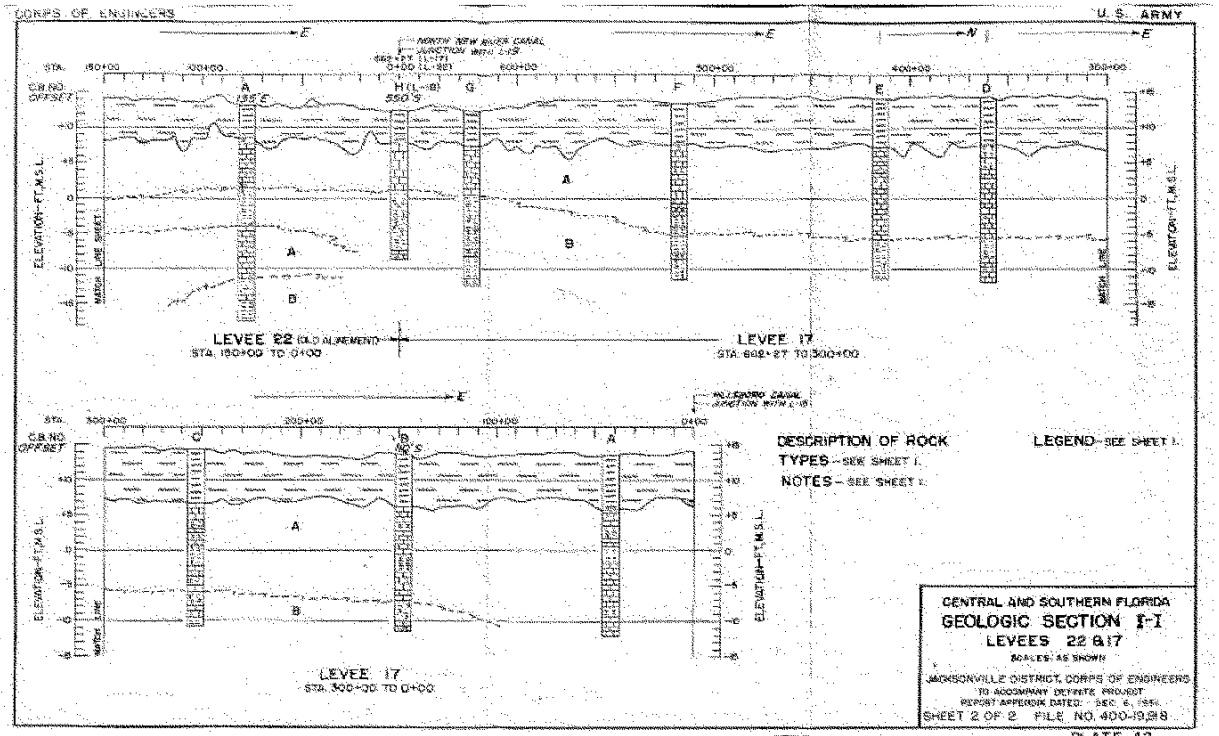


Figure G-4. Geologic Section L-22 & L-17

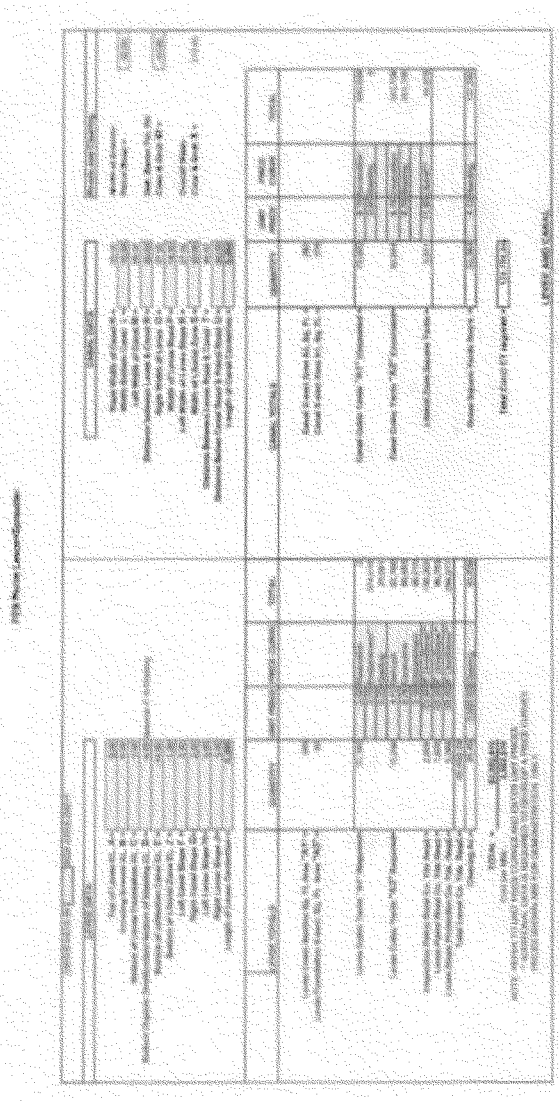


Figure G-5 FEB Seepage Model Input Data

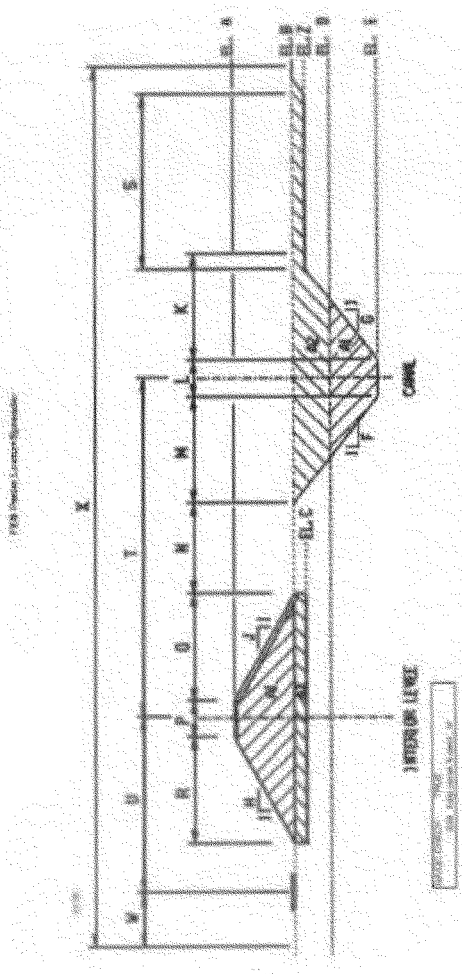


Figure G-6: FEB Seepage Model Hawkins Cross Section Geometry

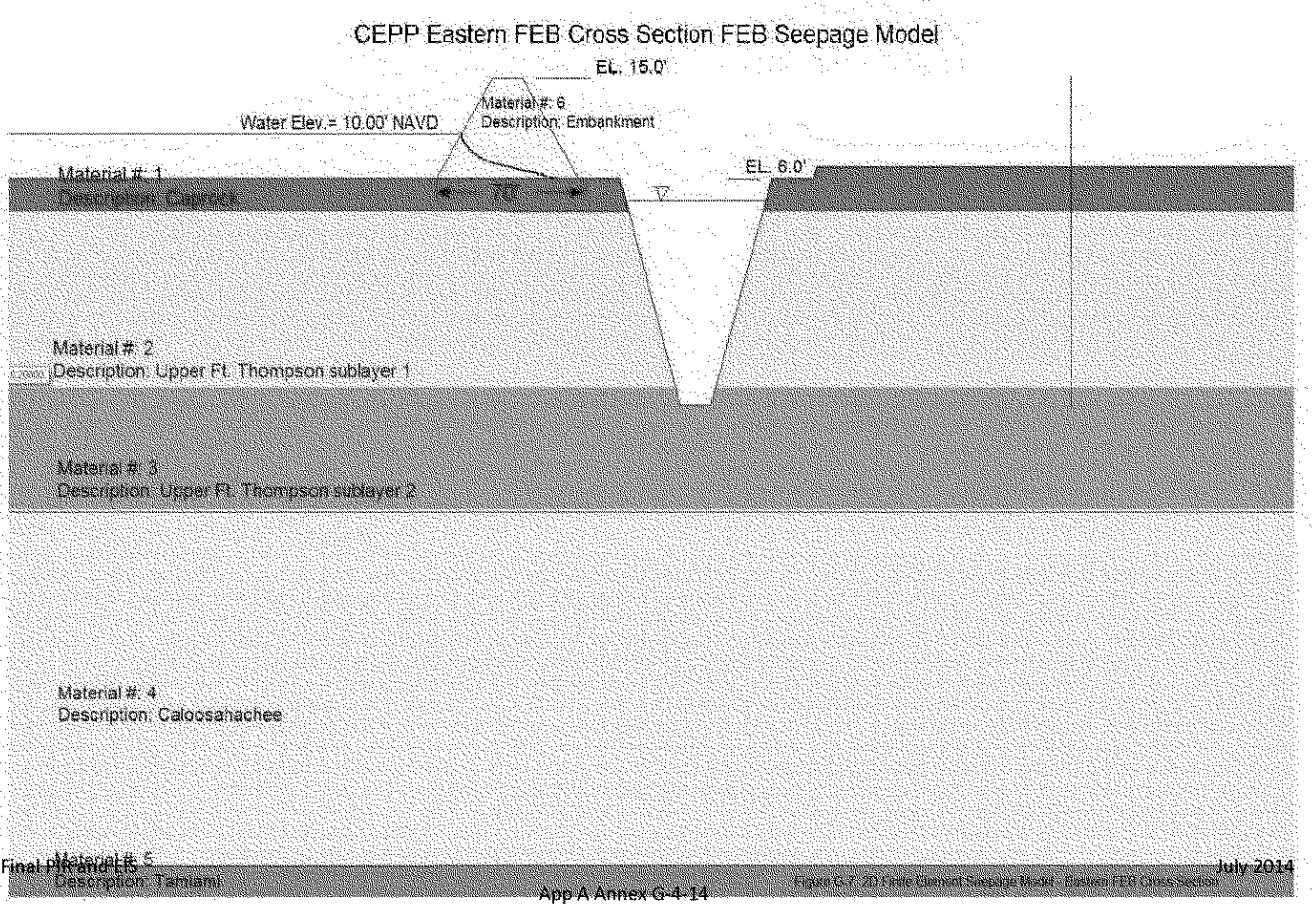
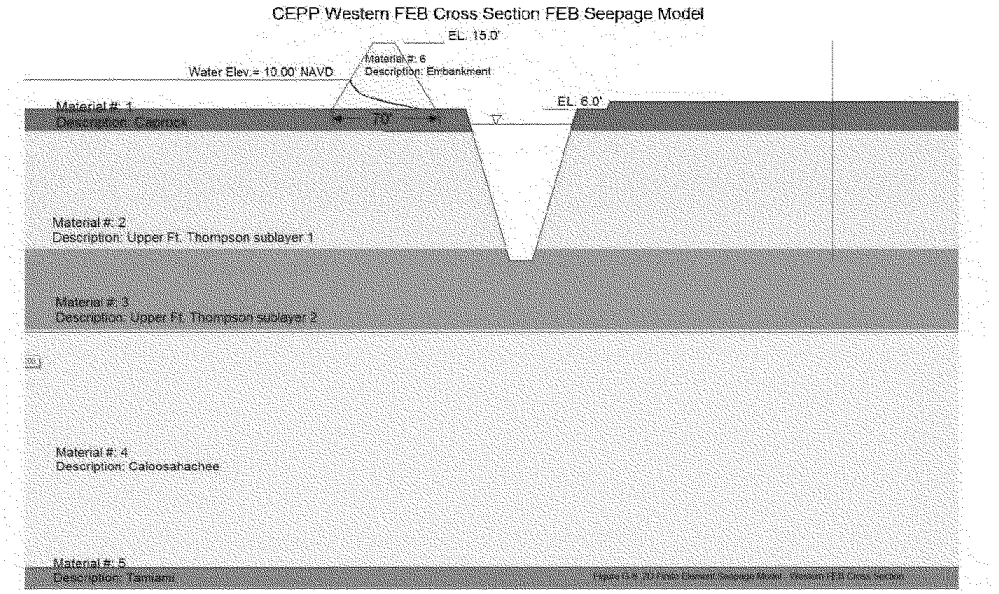


Figure G-7. 2D Finite Element Seepage Model - Eastern FEB Cross Section


CEPP Western FEB Cross Section FEB Seepage Model
EL. 15.0'
Material #: 6
Description: Embankment
Water Elev.= 10.00' NAVD
EL. 6.0'
Material #: 1
Description: Caprock
70'
Material #: 2
Description: Upper Ft. Thompson sublayer 1
Material #: 3
Description: Upper Ft. Thompson sublayer 2
Material #: 4
Description: Caloosahachee
Material #: 5
Description: Tamiami

APPENDIX G

CORE BORING

CP02-EAARS-CB-0002

Boring Designation CP02-EAARS-CB-0002

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District
SHEET 1 OF 10 SHEETS	
1. PROJECT: CERP Everglades Agricultural Area Reservoirs – Phase 1, Effort 1, Compartment A	9. SIZE AND TYPE OF BIT: See Remarks
10. COORDINATE SYSTEM-DATUM: State Plane, FLE / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
2. BORING DESIGNATION: CP02-EAARS-CB-0002 / LOCATION COORDINATES: X = 736,775 Y = 775,528	11. MANUFACTURER'S DESIGNATION OF DRILL: CME-55 / ☐ AUTO HAMMER ☒ MANUAL HAMMER
3. DRILLING AGENCY: Andaman & Associates, Inc. / CONTRACTOR FILE NO.: 02-042	12. TOTAL SAMPLES: DISTURBED 118 / UNDISTURBED (UD) 0
4. NAME OF DRILLER: M. Gulick	13. TOTAL NUMBER CORE BOXES: 5
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED / DEG. FROM VERTICAL / BEARING	14. ELEVATION GROUND WATER: Not Determined
	15. DATE BORING: STARTED 08-13-02 / COMPLETED 09-03-02
6. THICKNESS OF OVERBURDEN: 5.4 Ft.	16. ELEVATION TOP OF BORING: 12.0 Ft.
7. DEPTH DRILLED INTO ROCK: 13.5 Ft.	17. TOTAL RECOVERY FOR BORING: 80 %
8. TOTAL DEPTH OF BORING: 180.0 Ft.	18. SIGNATURE AND TITLE OF INSPECTOR: H. Snyder, Civil Engineer

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	SIZE OF SAMPLE	ROD OR CORE US	REMARKS	BLOWS PER 6 IN.	N-VALUE
12.0	0.0						12.0		
			FILL, gravelly, mixture of fine gravel size limestone, fine to coarse grained limestone sand, and silt, dry, light grey	13	1		SPT Sampler	32 / 32 / 8	40
							10.4		
				40	2		SPT Sampler	4 / 6 / 6	12
9.0	3.0						9.0		
8.6	3.4		SAND, silty, mostly fine-grained, some silt, dry, dark brown (SM)	47	3		SPT Sampler	1 / 2 / 4	6
			Limestone, hard, slightly weathered, medium-grained, porous to pitted, light gray-green				7.4		
				100	4		SPT Sampler	16 / 50/0.4'	
							6.6		
5.0	7.0		Limestone, moderately hard	50	5 BOX 1	RQD 28	4 x 5-1/2" Diamond Impregnated Bit DT = 80 mins HP = 100 psi		
							2.0		
				100	7	RQD 0	4 x 5-1/2" Diamond Impregnated Bit 9 mins, 100 psi		
							0.9		
				80	8		SPT Sampler	4 / 4 / 29	33
							0.6		
				50	9		-1.0 SPT Sampler	50/0.4'	
				45	BOX 2	RQD 39	4 x 5-1/2" Diamond Impregnated Bit DT = 23 mins HP = 100 psi		

Slight Washout

SAJ FORM 1836
JUN 02

(Continued)

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Boring Designation CP02-EAARS-CB-0002

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 2 OF 10 SHEETS
PROJECT: CERP Everglades Agricultural Area Reservoirs	COORDINATE SYSTEM/DATUM: State Plane, FLE / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 736,775 Y = 775,528	ELEVATION TOP OF BORING: 12.0 Ft.	

ELEV.	DEPTH	LOGGED	CLASSIFICATION OF MATERIALS	NO.	RECOVERY / RQD	REMARKS	BLOWS PER 6 INCHES	N-VALUE
			At El. -3.0 Ft., vuggy	45	RQV 39	4 x 5-1/2" Diamond Impregnated Bit		
-4.0	16.0				RQD	DT = 33 mins		
			Limestone, hard, unweathered, fine-grained, vuggy, trace of shell, gray	NR	11	HP = 100 psi	50/0.2	
						-4.2 SPT Sampler		
				84	RQV 50 RQD	4 x 5-1/2" Diamond Impregnated Bit DT = 15 mins HP = 100 psi		
						-8.0		
				70	RQV 50 RQD 46	4 x 5-1/2" Diamond Impregnated Bit 8 mins, 100 psi		
			At El. -9.0 Ft., little shell			-9.0		
				32	14	SPT Sampler	5 7 8	15
			At El. -10.6 Ft., trace silt			-10.6		
				47	15	SPT Sampler	7 9 10	19
-12.0	24.0					-12.0		
			SAND, poorly-graded with silt, some angular fine-grained quartz, some fine-grained limestone, little angular shell, trace phosphate, light brown (SP-SM)	47	16	SPT Sampler	7 10 11	21
						-13.6		
				47	17	SPT Sampler	11 10 11	21
-15.0	27.0					-15.0		
			SAND, silty, mostly fine grained quartz, trace angular fine-grained shell, trace clay, trace phosphate, light gray (SM)	73	18	SPT Sampler	8 9 9	18
						-16.6		
			At El. -17.0 Ft., little clay	87	19	SPT Sampler	7 6 6	12
						-18.0		
				97	20	SPT Sampler	8 5 5	10
-19.6	31.6					-19.6		
			SAND, poorly-graded with silt, mostly fine-grained quartz, little shell, low silt, light brown (SP-SM)	73	21	SPT Sampler	8 8 12	20
						-21.0		
				73	02	SPT Sampler	10 11 13	24
-22.6	34.6					-22.6		
			SAND, poorly-graded, mostly fine to	75	23	SPT Sampler	11	

(Continued)

SAJ FORM 1836-A
JUN 02

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Boring Designation CP02-EAARS-CB-0002

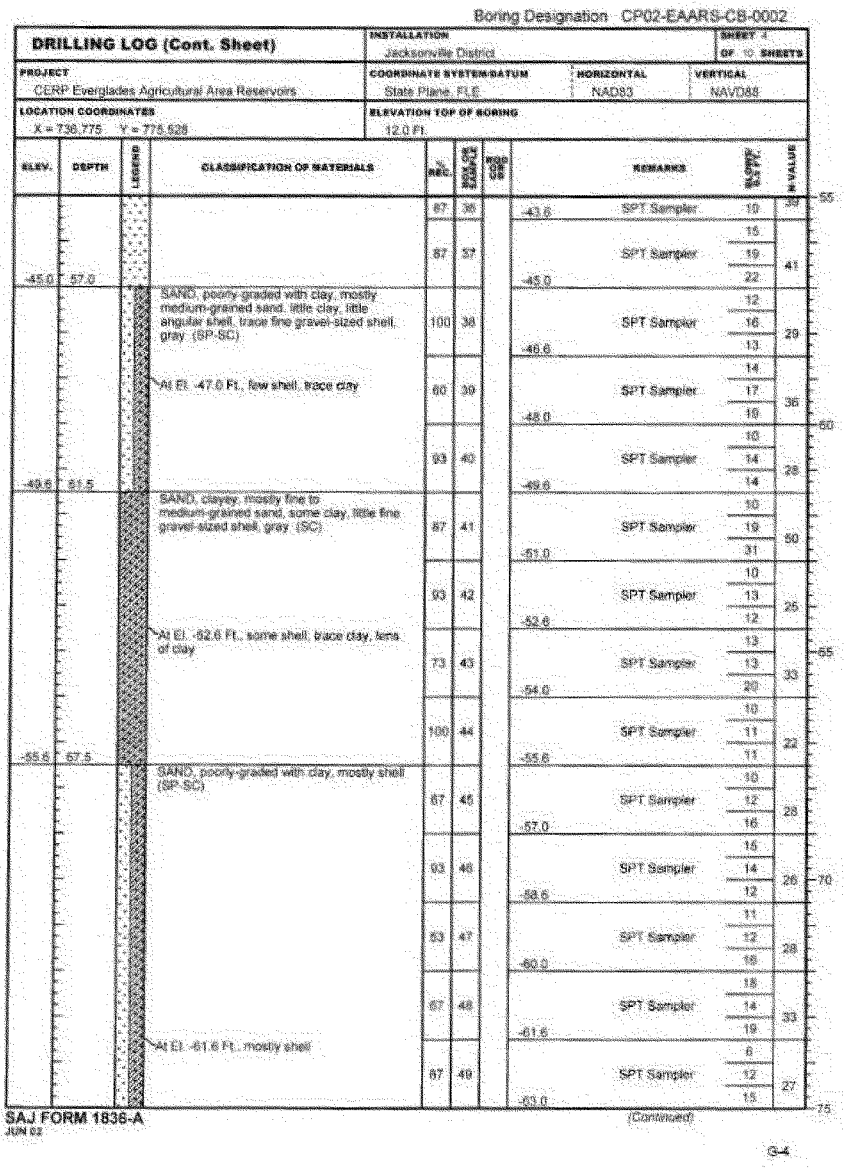
DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET 3 OF 15 SHEETS
PROJECT: CEPP Everglades Agricultural Area Reservoir	COORDINATE SYSTEM/DATUM: State Plane, FLE / HORIZONTAL: NAD83 / VERTICAL: NAVD88	
LOCATION COORDINATES: X = 736,775 Y = 775,526	ELEVATION TOP OF BORING: 52.0 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	NO.	RECOVERY (%)	STRATA CHANGE	REMARKS	BLOWS/0.5FT	N-VALUE
			medium-grained quartz, some angular fine to medium-grained shell, few phosphate, trace silt, light brown to light gray (SP)	75	23		SPT Sampler	11 / 11	22
			*At El. -24.0 Ft., trace shell, trace of shell	93	24		SPT Sampler	6 / 7 / 8	15
				67	29		SPT Sampler	3 / 5 / 5	10
				67	26		SPT Sampler	4 / 6 / 7	13
			*At El. -30.0 Ft., trace fine gravel-sized shell	73	27		SPT Sampler	5 / 5 / 7	12
				60	28		SPT Sampler	5 / 5 / 8	13
				93	29		SPT Sampler	7 / 4 / 7	11
			*At El. -34.6 Ft., trace fine gravel-sized limestone	80	30		SPT Sampler	10 / 8 / 8	16
				93	31		SPT Sampler	10 / 8 / 11	19
36.8	46.0		Limestone, hard, fine-grained, trace of silt, few fine grained sand, trace of clay, gray	93	32		SPT Sampler	9 / 29 / 34	63
				53	33		SPT Sampler	14 / 6 / 9	15
39.0	51.8		SAND, poorly-graded, mostly fine-grained shell, trace coarse gravel-sized phosphate, trace clay, gray (SP)	80	34		SPT Sampler	4 / 5 / 6	11
			*From El. -40.6 to -45.0 Ft., mostly medium to coarse-grained shell, trace fine gravel-sized shell, trace clay, light brown	73	35		SPT Sampler	11 / 19 / 26	45
				87	36		SPT Sampler	17 / 28	55

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JUN 02

(Continued)

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Boring Designation CP02-EAARS-CB-0002

DRILLING LOG (Cont. Sheet)

INSTALLATION: Jacksonville District — SHEET 4 OF 10 SHEETS

PROJECT: CERP Everglades Agricultural Area Reservoirs

COORDINATE SYSTEM/DATUM: State Plane, FLE — HORIZONTAL: NAD83 — VERTICAL: NAVD88

LOCATION COORDINATES: X = 736,775 Y = 775,526

ELEVATION TOP OF BORING: 12.0 Ft.

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	% RQD	BLOW COUNTS	REMARKS	BLOWS/FT.	N VALUE
				67	36		-43.6 SPT Sampler	10	39
				67	37		SPT Sampler	15 19	41
-45.0	57.0						-45.0	22	
			SAND, poorly graded with clay, mostly medium-grained sand, little clay, little angular shell, trace fine gravel-sized shell, gray (SP-SC)	100	38		SPT Sampler	12 16	29
							-46.6	13	
			At El. -47.0 Ft., few shell, trace clay	60	39		SPT Sampler	14 17	36
							-48.0	19	
				93	40		SPT Sampler	10 14	28
-49.6	61.5						-49.6	14	
			SAND, clayey, mostly fine to medium-grained sand, some clay, little fine gravel-sized shell, gray (SC)	87	41		SPT Sampler	10 19	50
							-51.0	31	
				93	42		SPT Sampler	10 13	25
			At El. -52.6 Ft., some shell, trace clay, lens of clay				-52.6	12	
				73	43		SPT Sampler	13 13	33
							-54.0	20	
				100	44		SPT Sampler	10 11	22
-55.6	67.5						-55.6	11	
			SAND, poorly-graded with clay, mostly shell (SP-SC)	67	45		SPT Sampler	10 12	28
							-57.0	16	
				93	46		SPT Sampler	15 14	26
							-58.6	12	
				53	47		SPT Sampler	11 12	28
							-60.0	16	
				67	48		SPT Sampler	18 14	33
			At El. -61.6 Ft., mostly shell				-61.6	19	
				67	49		SPT Sampler	8 12	27
							-63.0	15	

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JUN 02

(Continued)

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Boring Designation CP02-EAARS-CB-0002

DRILLING LOG (Cont. Sheet)

INSTALLATION: Jacksonville District — SHEET 6 OF 10 SHEETS

PROJECT: CERP Everglades Agricultural Area Reservoirs

COORDINATE SYSTEM/DATUM: State Plane, FLE — HORIZONTAL: NAD83 — VERTICAL: NAVD88

LOCATION COORDINATES: X = 736,776 Y = 775,528

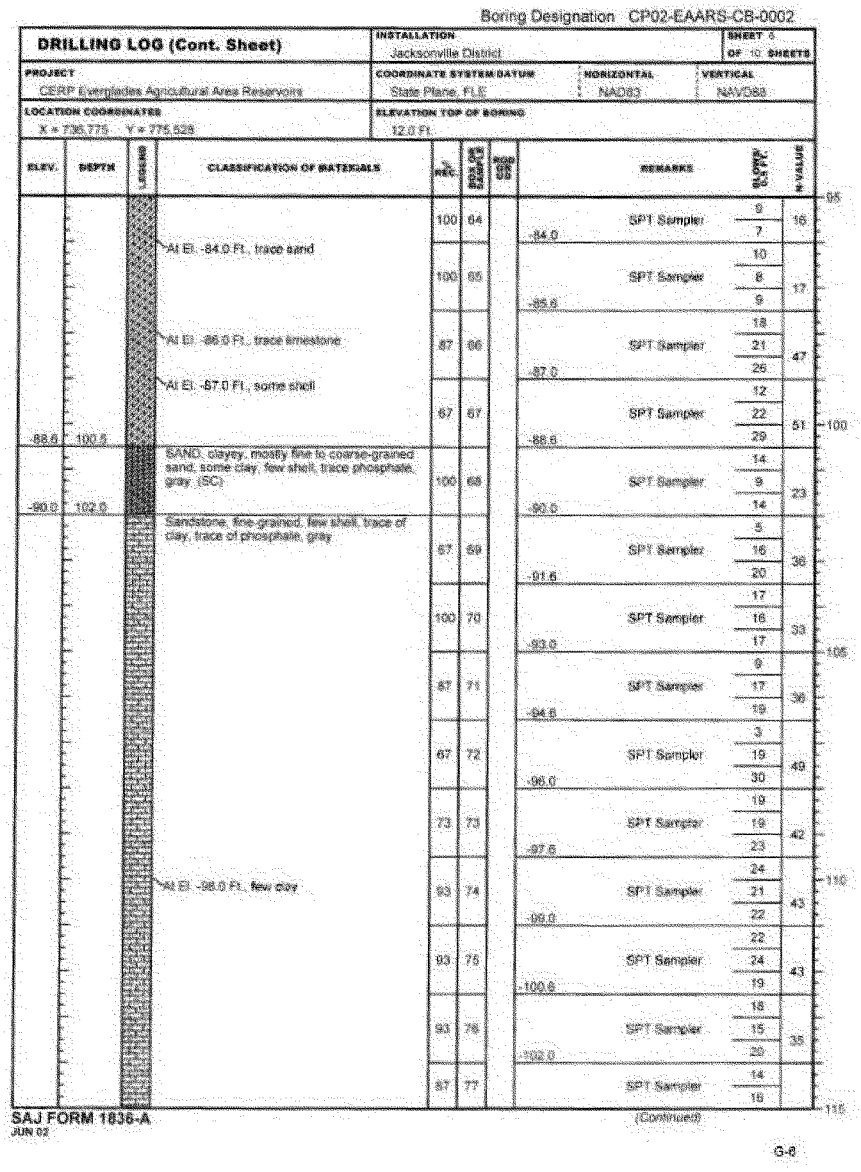
ELEVATION TOP OF BORING: 12.0 Ft.

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	ROCK QUALITY DESIG.	ROD OR CORE	REMARKS	BLOWS/0.5 FT.	N-VALUE
-63.6	75.7		Limestone, fine-grained, trace of clay, trace of phosphate, gray	93	50		SPT Sampler	20 18 19	38
-64.6									
-66.0	78.0			53	51		SPT Sampler	14 16 17	33
			SAND, poorly-graded, mostly fine to medium-grained quartz, trace sandstone, trace shell, light gray (SP)	67	52		SPT Sampler	19 40 45	85
-67.6				67	53		SPT Sampler	26 32 49	81
-69.0				100	54		SPT Sampler	36 65 57	122
-70.6				87	55		SPT Sampler	10 14 20	34
-72.0				93	56		SPT Sampler	14 28 29	57
-73.6				53	57		SPT Sampler	14 17	
-75.0				57	59		SPT Sampler	8 18 29	47
-76.6				87	60		SPT Sampler	24 34 42	76
-78.0				73	61		SPT Sampler	9 18 20	38
-79.6			From El. -79.6 to -80.6 Ft., mostly coarse-grained quartz, trace phosphate, trace shell, trace sandstone, light gray	93	62		SPT Sampler	4 10 6	16
-80.6	92.6		SAND, clayey, mostly medium to coarse-grained sand, some clay, trace phosphate, trace shell, gray (SC)						
-81.0				100	63		SPT Sampler	5 7 12	19
-82.6			At El. -82.0 Ft., trace sand At El. -82.6 Ft., little shell, little limestone	100	64		SPT Sampler	3	

SAJ FORM 1836-A
JUN 02

(Continued)

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Boring Designation CP02-EAARS-CB-0002

DRILLING LOG (Cont. Sheet)

INSTALLATION: Jacksonville District — SHEET 6 OF 10 SHEETS

PROJECT: CERP Everglades Agricultural Area Reservoirs

COORDINATE SYSTEM/DATUM: State Plane, FLE — HORIZONTAL: NAD83 — VERTICAL: NAVD88

LOCATION COORDINATES: X = 736,775 Y = 775,529

ELEVATION TOP OF BORING: 12.0 Ft.

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	ROCK QUALITY DESIGN	CORE SIZE	REMARKS	BLOWS/6 IN. OR PEN.	N-VALUE
							-84.0 SPT Sampler	9 / 7	16
			At El. -84.0 Ft., trace sand	100	64				
							-85.6 SPT Sampler	10 / 8 / 9	17
				100	65				
			At El. -86.0 Ft., trace limestone				-87.0 SPT Sampler	18 / 21 / 26	47
				87	66				
			At El. -87.0 Ft., some shell				-88.6 SPT Sampler	12 / 22 / 29	51
-88.6	100.6			67	67				
			SAND, clayey, mostly fine to coarse-grained sand, some clay, few shell, trace phosphate, gray (SC)				-90.0 SPT Sampler	14 / 9 / 14	23
-90.0	102.0			100	68				
			Sandstone, fine-grained, few shell, trace of clay, trace of phosphate, gray				-91.6 SPT Sampler	5 / 16 / 20	36
				67	69				
							-93.0 SPT Sampler	17 / 16 / 17	33
				100	70				
							-94.6 SPT Sampler	9 / 17 / 19	36
				87	71				
							-96.0 SPT Sampler	3 / 19 / 30	49
				67	72				
							-97.6 SPT Sampler	19 / 19 / 23	42
				73	73				
			At El. -98.0 Ft., few clay				-99.0 SPT Sampler	24 / 21 / 22	43
				93	74				
							-100.6 SPT Sampler	22 / 24 / 19	43
				93	75				
							-102.0 SPT Sampler	18 / 15 / 20	35
				93	76				
							SPT Sampler	14 / 16	
				87	77				

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JUN 02

(Continued)

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Boring Designation CP02-FAARS-CB-0002

DRILLING LOG (Cont. Sheet)

INSTALLATION: Jacksonville District			SHEET 1 OF 10 SHEETS
PROJECT: CERP Everglades Agricultural Area Reservoirs	COORDINATE SYSTEM/DATUM: State Plane, FLE	HORIZONTAL: NAD83	VERTICAL: NAVD88
LOCATION COORDINATES: X = 736,775 Y = 775,328	ELEVATION TOP OF BORING: 12.0 Ft		

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	NO.	RECOVERY	ROCK QUALITY DESIGNATION	REMARKS	BLOWS/FT.	
				97	72		-103.6 SPT Sampler	17	33
				87	76		SPT Sampler	16 17 14	31
							-106.0		
				93	79		SPT Sampler	12 10 11	21
							-108.6		
				100	80		SPT Sampler	16 17 16	33
							-109.6		
				93	81		SPT Sampler	12 14 18	32
							-111.0		
				97	82		SPT Sampler	17 22 17	39
							-112.6		
				93	83		SPT Sampler	12 10 16	32
							-114.0		
				73	84		SPT Sampler	14 22 19	41
							-115.6		
				87	85		SPT Sampler	15 14 13	27
							-117.0		
				93	86		SPT Sampler	14 13 13	26
							-118.6		
				73	87		SPT Sampler	13 14 10	24
							-120.0		
				87	88		SPT Sampler	9 12 15	25
							-121.6		
				80	89		SPT Sampler	26 16 16	31
							-123.0		
				87	90		SPT Sampler	23 24 18	42

SAJ FORM 1836-A
JUN 02

(Continued)

0-7

Boring Designation CP02-EAARS-CB-0002

DRILLING LOG (Cont. Sheet)

INSTALLATION: Jacksonville District — SHEET 2 OF 10 SHEETS

PROJECT: CERP Everglades Agricultural Area Reservoirs

COORDINATE SYSTEM/DATUM: State Plane, FLE — HORIZONTAL: NAD83 — VERTICAL: NAVD88

LOCATION COORDINATES: X = 736,775 Y = 775,528

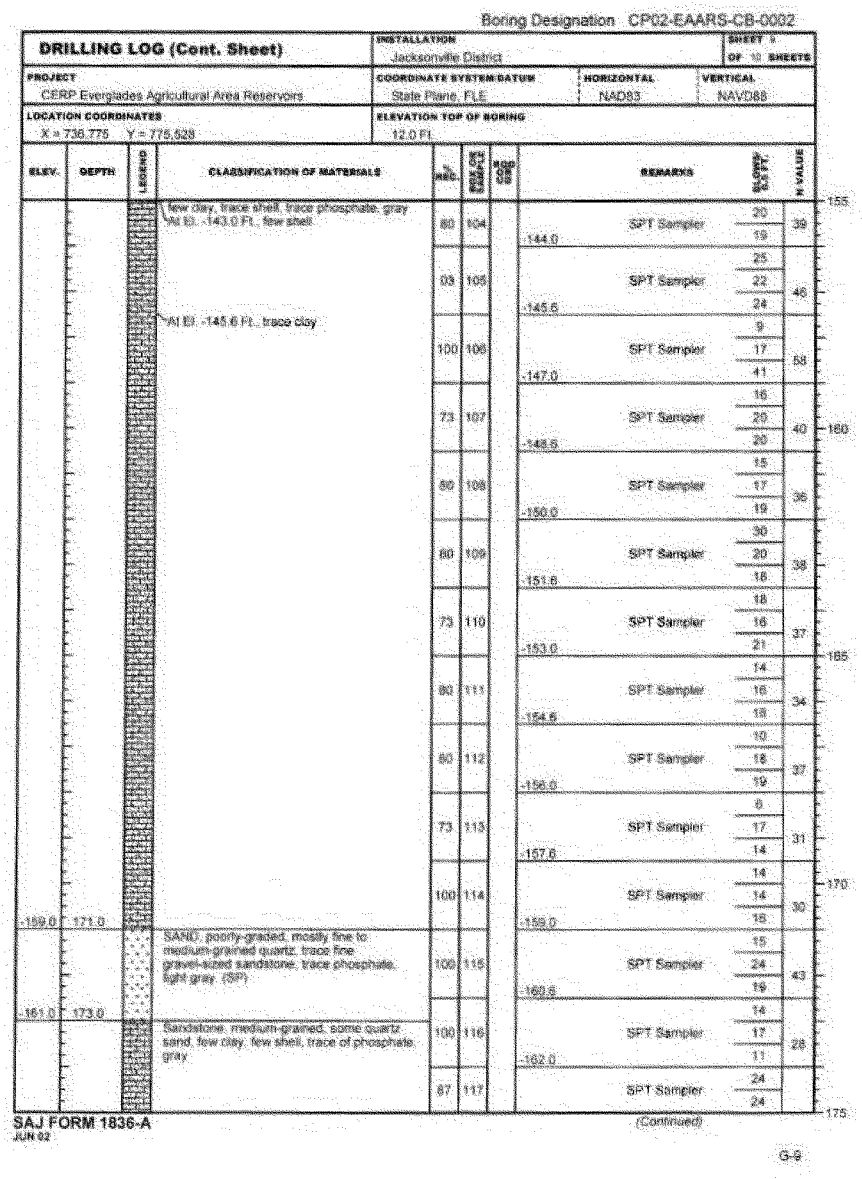
ELEVATION TOP OF BORING: 12.0 Ft

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	RQD OR CORE %	CORE RUN	REMARKS	BLOWS/6 IN.	N-VALUE
				90	91		SPT Sampler	9 10 11	21
-124.6									
				93	92		SPT Sampler	17 24 19	43
-126.0									
				80	93		SPT Sampler	25 28 20	48
-127.6									
				73	94		SPT Sampler	14 18 19	37
-129.0									
				87	95		SPT Sampler	12 16 39	55
-130.6									
-131.0	143.0		SAND, poorly-graded, mostly fine to medium-grained quartz, trace phosphate, light gray (SP)	100	96		SPT Sampler	31 37 24	61
-132.0									
				100	97		SPT Sampler	17 21 17	38
-133.6									
				100	98		SPT Sampler	14 16 20	36
-135.0									
				100	99		SPT Sampler	12 25 27	52
-136.6									
				100	100		SPT Sampler	12 18 18	36
-138.0									
				93	101		SPT Sampler	11 16 18	34
-139.6									
				100	102		SPT Sampler	10 16 22	38
-141.0									
				87	103		SPT Sampler	15 26 25	51
-142.6	154.5		Sandstone, fine-grained, some quartz sand,	80	104		SPT Sampler	18	

(Continued)

SAJ FORM 1836-A
JUN 02

G-8



Boring Designation CP02-EAARS-CB-0002

DRILLING LOG (Cont. Sheet)

INSTALLATION: Jacksonville District

SHEET 9 OF 10 SHEETS

PROJECT: CERP Everglades Agricultural Area Reservoirs

COORDINATE SYSTEM/DATUM: State Plane, FLE

HORIZONTAL: NAD83

VERTICAL: NAVD88

LOCATION COORDINATES: X = 736,775 Y = 775,528

ELEVATION TOP OF BORING: 12.0 Ft.

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BLOWS/6 IN	ROD SIZE	REMARKS	BLOWS/0.5 FT	N VALUE
			few clay, trace shell, trace phosphate, gray At El. -143.0 Ft., few shell At El. -145.6 Ft., trace clay	80	104		-144.0 SPT Sampler	20 19	39
				09	105		-145.5 SPT Sampler	25 22 24	46
				100	106		-147.0 SPT Sampler	9 17 41	58
				73	107		-148.6 SPT Sampler	16 20 20	40
				80	108		-150.0 SPT Sampler	15 17 19	36
				80	109		-151.6 SPT Sampler	30 20 18	38
				73	110		-153.0 SPT Sampler	18 16 21	37
				80	111		-154.6 SPT Sampler	14 16 18	34
				80	112		-156.0 SPT Sampler	10 18 19	37
				73	113		-157.6 SPT Sampler	8 17 14	31
-159.0	171.0			100	114		-159.0 SPT Sampler	14 14 16	30
			SAND, poorly-graded, mostly fine to medium-grained quartz, trace fine gravel-sized sandstone, trace phosphate, light gray (SP)	100	115		-160.6 SPT Sampler	15 24 19	43
-161.0	173.0								
			Sandstone, medium-grained, some quartz sand, few clay, few shell, trace of phosphate, gray	100	116		-162.0 SPT Sampler	14 17 11	28
				87	117		SPT Sampler	24 24	

(Continued)

SAJ FORM 1836-A
JUN 02

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Boring Designation: CP02-EAARS-CB-0002

DRILLING LOG (Cont. Sheet)	INSTALLATION: Jacksonville District	SHEET ½ OF ½ SHEETS
PROJECT: CEPP Everglades Agricultural Area Reservoir	COORDINATE SYSTEM/DATUM: State Plane, FLE	HORIZONTAL: NAD83 / VERTICAL: NAVD88
LOCATION COORDINATES: X = 736,776 Y = 775,528	ELEVATION TOP OF BORING: 12.0 Ft.	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	REC.	BOX NO. 2304-2	REC. CORE	REMARKS	BLOWS/6" N-VALUE	
				57	117		163.8 SPT Sampler	18	42
				57	118		SPT Sampler	16 18 18	34
				100	119		165.0 SPT Sampler	17 18 19	37
				100	120		166.8 SPT Sampler	25 26 29	55
-168.0	180.0						166.0		

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

2. Laboratory Testing Results

SAMPLE ID	SAMPLE DEPTH	LABORATORY CLASSIFICATION
119	177.0/178.8	*

*Lab visual classification based on gradation curve. No Atterberg limits.

3. Additional Laboratory Testing

119 Moisture Content

140# hammer w/30" drop used with 2.0" split spoon (1-3/8" I.D. x 2" O.D.)

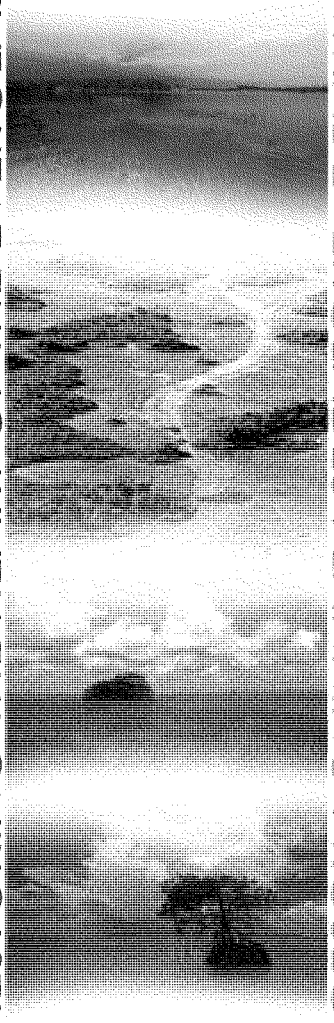
Abbreviations:
NR = Not Recorded
DT = Drill Time
HP = Hydraulic Pressure

SAJ FORM 1836-A
JUN 02

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RESTORING THE HEART OF THE EVERGLADES

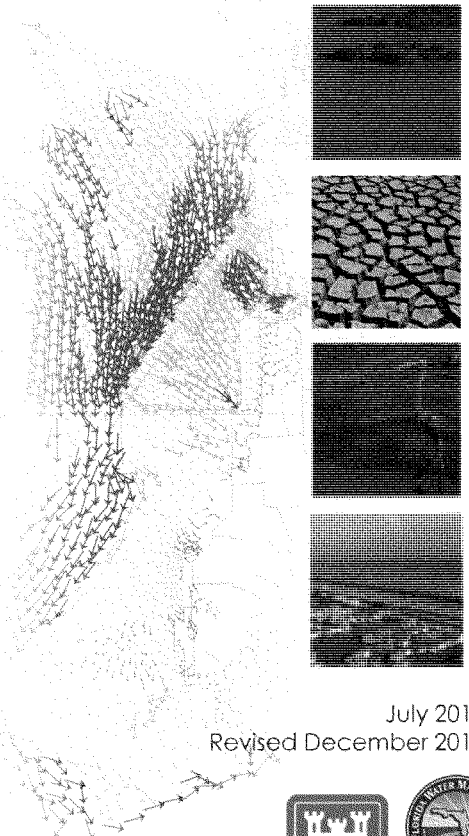
CENTRAL EVERGLADES PLANNING PROJECT



COMPREHENSIVE EVERGLADES RESTORATION PLAN

CENTRAL EVERGLADES PLANNING PROJECT

FINAL INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT



July 2014
Revised December 2014

Appendix B

Cover insets (left to right):

Landscapes: Lake Okeechobee, Water Conservation Area 3, Everglades National Park, Florida Bay; **Map:** Depicts Average Annual Overland Flow across the period of record (1965-2005) for existing conditions, as modeled by the CEPP regional hydrologic model (the coloration of the arrows represents the relative volume of flow, while the direction of the arrows represents the movement of flow across the landscape); **Small Landscapes:** Ponding, soil oxidation (peat reduction), dry area of Everglades National Park, juxtaposition of urban development.

APPENDIX B

COST ENGINEERING APPENDIX

COST ESTIMATES AND RISK ANALYSIS

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ATTACHMENTS TO APPENDIX B

ATTACHMENT A: PROJECT COST CERTIFICATION
ATTACHMENT B: PROJECT RISK MANAGEMENT PLAN with COST AND SCHEDULE RISK ANALYSIS REPORT
ATTACHMENT C: PROJECT QUANTITY TAKEOFFs AND ASSUMPTIONS

B.0 COST ENGINEERING

B.1 GENERAL INFORMATION

Corps of Engineers cost estimates for planning purposes are prepared in accordance with the following guidance:

- Engineer Technical Letter (ETL) 1110-2-573, Construction Cost Estimating Guide for Civil Works, 30 September 2008
- Engineer Regulation (ER) 1110-1-1300, Cost Engineering Policy and General Requirements, 26 March 1993
- ER 1110-2-1302, Civil Works Cost Engineering, 15 September 2008
- ER 1110-2-1150, Engineering and Design for Civil Works Projects, 31 August 1999
- ER 1105-2-100, Planning Guidance Notebook, 22 April 2000, as amended
- Engineer Manual (EM) 1110-2-1304 (Tables Revised 31 March 2009), Civil Works Construction Cost Index System, 31 March 2000
- CECW-CP Memorandum for Distribution, Subject: USACE Civil Works Feasibility Study Program Execution and Delivery, 8 February 2012
- CECW-CP Memorandum for Distribution, Subject: Initiatives to Improve the Accuracy of Total Project Costs in Civil Works Feasibility Studies Requiring Congressional Authorization, 19 September 2007
- CECW-CE Memorandum for Distribution, Subject: Application of Cost Risk Analysis
- Methods to Develop Contingencies for Civil Works Total Project Costs, 3 July 2007
- Cost and Schedule Risk Analysis Process, March 2008
- Engineering and Construction Bulleting (ECB) 2012-18, Engineering Within the Planning Modernization Paradigm, 18 May 2012

The goal of the cost estimates for the Central Everglades Planning Project Study are to present a Total Project Cost (Construction and Non-Construction costs) for the recommended plan at the current price level to be used for project authorization and to escalate costs for budgeting purposes. In addition, the costing efforts are intended to produce a final product (cost estimate) that is reliable and accurate, and that supports the definition of the Government's and the Non-Federal sponsor's obligations.

The cost estimating effort for the study also yielded a series of alternative plan formulation cost estimates for decision making. The final set of plan formulation cost estimates used for plan selection relies on historic construction feature unit pricing. The cost estimate supporting the National Ecosystem Restoration plan (Recommended Plan/Locally Preferred Alternative Plan) is prepared in MCACES/MII format to the Civil Works Work Breakdown Structure (CWWBS) sub-feature level. This estimate is supported by the preferred labor, equipment, materials and crew/production breakdown. A fully funded (escalated for inflation through project completion) cost estimate, the Baseline Cost Estimate or Total Project Cost Summary has been produced by the Cost MCX for the draft report. A risk analysis has been produced by the Cost MCX for the draft report. It addresses the project uncertainties and sets contingencies for the Recommended Plan's cost items. An initial cost risk workshop was held during the week of February 4, through February 8, 2013. The workshop included reviewing and discussing risks associated with each feature, while team members appraised the

features separately. The cost estimates were prepared using the data provided by the Project Delivery Team (PDT) and a series of assumptions that were input into the Parametric Costing Tool. The Parametric Cost tool was created by the sponsor South Florida Water Management District. This tool combined project estimates from completed projects as well as estimated costs from larger type projects such as Modified Waters Delivery (MWD) and Everglades Agricultural Area (EAA).

This Parametric Cost tool was a major factor in the process of screening potential features and components of the overall project. The tool estimated costs and generated quantities based on factors and presets from multiple resource points that were built into the Microsoft Access database. The tool did have a few pitfalls such as not being able to capture the entirety of the scope. Some items, such as real estate, O&M and contingencies had to be created outside of the tool for completion and then combined with the total for a total cost.

An Agency Technical Review (ATR) was completed on the Draft Cost Appendix dated February 15, 2013. The MCX had concerns about the Cost ATR effort and reviewing the final array of alternatives focusing on the supporting data that confidently establishes the recommended plan as the reasonable plan, worthy of USACE support in pursuing Federal funds through the Assistant Secretary of the Army's office. A potential recommended plan is ready for HQUSACE decision and commitment once the recommended plan is established from various alternatives with the associated confident comparative costs. The resolution for this is better cost traceability, development of preliminary scope, quantities, parametric costs and associated risks for each alternative. These costs must be clearly developed, calculated and presented. Another item of concern for the MCX is that the data presented in the first submission was inadequate and the resolution for this is to note the Cost ATR comments as a means of supporting better quality products that lend confidence that everyone made the right choice at the right estimate cost.

Second Cost Schedule Risk Analysis Workshop was conducted June 18 and 19, 2013. PDT participants from multiple agencies discussed the high risk items identified in first risk analysis workshop and identified additional risks.

Following this two day workshop a third step was undertaken to further reduce risk associated with uncertainty of specific site conditions. The local sponsor and USCE engineers, construction and cost personnel, held a meeting between June 25 through 28, 2013, and revisited and refined costs scope with respect to particular means of performing construction work, confirming site specific assumptions with respect to subsurface conditions, hauling, material processing, care and diversion of water, and etc. This information assisted in the final development of the recommended plan costs for the project.

These cost schedule risk analysis workshops and the meetings with the Sponsor in June 2013 proved to be a successful partnering opportunity. It reduced the total cost and contingencies developed during the screening of alternatives to those developed for the recommended plan from $2.2B (82% contingency) to $1.9B (44% contingency). During the process of developing preliminary costs, a comparison/reasonable check was prepared of the costs of similar features proposed in CEPP's predecessor, The Yellow Book. The differences between the similar features were less than $200M. Lastly, an analysis of the contingencies for eleven of the past planning documents (post-certification) prepared by Jacksonville Districts resulted in a range of 20-40%. CEPP's contingency of 44% is slightly higher than the range; however, CEPP is consistent with the pilot concept of using existing data and best professional judgment in lieu of expending additional resources for site specific data collection.

COST COMPARISON - CERP (YELLOWBOOK) AND CEPP

CEPP AND CEPP FEATURE DESCRIPTIONS		FY08 Yellow book Costs Costs include PED and Construction Management Implementation Plan Construction & Real Estate	Cost Appendix Construction Only	FY08 Yellow book without Real Estate Escalated Construction Cost to FY16 1.042664932 Cost Escalation Factor	CEPP Construction First Cost (includes contingency)
EAA Storage and Conveyance (G)		$ 436,648,000.00	$ 350,112,000.00	$ 575,116,920.72	$ 582,668,000.00
(G) EAA Storage Reservoirs 240k/ac ft (3 comp)		$ 350,112,000.00	$ 350,112,000.00	$ 575,116,920.72	
CEPP Flow Equalization Basin 60k/ac ft (1 comp) - A2 FEB					$ 546,826,000.00
Real Estate		$ 86,536,000.00			$ 36,842,000.00
Flow to Northwest and Central Water Conservation Area 3A (B, RR)		$ 20,377,000.00	$ 20,377,000.00	$ 90,720,257.72	$ 121,994,000.00
(RR) L-148 Relocation and spreader system		$ 20,240,000.00	$ 20,240,000.00	$ 34,088,865.72	
(B) C40A Modifications		$ 10,137,000.00	$ 10,137,000.00	$ 16,651,691.68	
CEPP S8 Modifications					$ 73,492,000.00
- B Diversion, L-6 Canal Improvements and Infrastructure					$ 104,229,000.00
- A Depends on pump station to maintain water supply					$ 47,718,000.00
Real Estate					
WCA 3 Decompartmentalization & Sheetflow Enhancement (AA, GG, HH*, QQ are 2 comb, ** QQ are 2 comb)		$ 212,437,000.00	$ 188,404,000.00	$ 304,843,679.29	$ 369,869,000.00
(AA) Additional S-345/S-349s (adding 3000 cfs, or 6 S-345 structures)		$ 48,450,000.00	$ 48,450,000.00	$ 79,587,154.86	
(QQ) Miami Canal backfill ~35 miles	*				
(QQ) Remove L-29 Levee and Canal Backfill (~25 miles)	*		$ 41,000,000		
(QQ) Bridge and Remove Tieback Trail (~31 miles)	*	$ 20,467,000.00			
Bridges and road raising between L-31N and L-28 levees					
(QQ) Remove L-68A Levee					
(QQ) Degrade L-67C Levee and Canal Backfill					
(QQ) Remove L-28 & L-28 setback levees and Canal Backfill					
(GG) Construct 8 passive weirs along L-67A (north of S-342S)			$ 89,671,000.00	$ 140,728,326.85	
(QQ) Backfill L-67A Canal from Tieback Trail (~2.5 miles north)					
(QQ) Relocate a single MWD S-348 (to create bridge within L-67A Canal)					
(QQ) Remove S-346, S-343 (A&B) and S-123 (A thru D)					
(HH) Remove Miami Canal W5 Deliveries/North New River Mods		$ 51,297,000.00	$ 51,297,000.00	$ 84,742,364.07	
Cert Miami Canal Backfill ~34.5 miles					$ 199,227,000.00
S-345 Rehr (New L-67A structures S-631, S-632 and S-633)					$ 76,111,000.00
Degrade L-67C Levee w/o Canal Backfill (~9 miles)					$ 9,553,000.00
Remove L-29 Levee w/o Canal Backfill (~6.5 miles)					$ 14,851,000.00
New L-67D Levee (~8.5 miles) L-67C to L-29					$ 119,960,000.00
New S-333N Structure just north of railroad 9-333					$ 16,760,000.00
New S-355W Pump Station in the L-29 Canal					$ 27,803,000.00
Real Estate		$ 75,279,000.00			
EAA/L-31N Seepage Management - And S-356 Structures (Q, V with pilot projects, and H1-3, V and costs, ** H are same)		$ 337,081,000.00	$ 262,076,000.00	$ 288,239,542.85	$ 294,764,000.00
(L) 360 Drive Rain -Recharge Area Reservoir (11 Nat'l		$ 52,448,000.00	$ 52,448,000.00	$ 80,172,547.04	
(V) Seepage Barrier (Cutoff) Wall	*				
(V) Seepage (Groundwater Wall)	*	$ 68,611,000.00	$ 68,611,000.00	$ 112,756,997.20	
(V) L-31N (Pilot Project)		$ 10,000,000.00	$ 10,000,000.00	$ 16,426,996.92	
(H) Remove MWD S-356 Pump Station					
(H) Relocate MWD S-357 Pump Station					
(H) Add New S-356 R & S Pump Stations (800 cfs) each					
(H) Relocate L31N Seepage Canal		$ 206,022,000.00	$ 131,017,000.00	$ 78,883,002.69	
CEPP Seepage Barrier (C-111?) Wall					$ 34,337,000.00
Add New S-356 Pump Station 1000 cfs					$ 50,834,000.00
Remove old Tieback Trail					$ 8,296,000.00
Remove L-67 extension					$ 13,668,000.00
Upgrade Broward canal improvements		$ 10,103,000.00	$ 10,103,000.00	$ 16,605,001.34	
Real Estate		$ 175,000,000.00			
Everglades Rain-Driven Operations (R)					
TOTAL		$ 1,006,543,000.00	$ 820,969,000.00	$ 1,258,919,699.51	$ 1,369,329,000.00
			Included with real estate	$ 1,869,429,678.08	
				Fed. Shr. 65%	$ 870,754,000.00
				TOTAL CERP	$ 2,240,183,000.00

Table B.13

CERP (YELLOWBOOK) AND CEPP COMPARISON TABLE

CERP AND CEPP FEATURE DESCRIPTION	CERP 1999	CEPP TSP	NOTES: INFRASTRUCTURE DIFFERENCES
EAA Storage and Conveyance (G)			
EAA Storage Reservoirs	X	P	CERP 360 kaf storage volume (3 compartment) vs CEPP 60 kaf (1 compartment)
Flow to Northwest and Central Water Conservation Area 3A (H, RR)			
S-140 Relocation and spreader system	X		
S-140 Modifications	X	X	CEPP coupled with S-8 Modifications for deliveries
S-8 Modifications		X	
L-6 Diversion, L-5 Canal improvements and infrastructure		X	
L-4 Degrade and pump station (to maintain water supply)		X	CEPP assumed L-4 degrade and native WCA2/WCA3A hydroperiods restoration components as pre-CERP
WCA 3 Decompartmentalization & Sheetflow Enhancement (AA, QQ, SS)			
(AA) Additional S-345/S-349s (adding 3000 cfs, or 4 S-345 structures) *	X	P	CERP 6 S-345/S-349s (adding 3000 cfs to 1500 cfs assumed from MWD) vs CEPP 1 S-345 (adding 1500 cfs, with no MWD features)
(QQ) Miami Canal Backfill ~35 miles	X	P	CERP ~35 miles (S-8 to S-31) vs CEPP ~ 13.5 miles (north of L-75)
(QQ) Remove L-29 Levee and Canal Backfill (~26 miles)	X	P	CERP removed ~ 20 miles (south of WCA 3A and WCA 3B) vs. CEPP removes ~4.3 miles without canal backfill
(QQ) Bridge and Elevate Tamiami Trail (~20 miles) Bridges and road raising between L-31N and L-28 levees *	X	*	CERP is dependent on completion of the DOI Tamiami Trail Next Steps project (~10 miles, south of WCA 3B)
(QQ) Remove L-67A Levee	X		
(QQ) Degrade L-67C Levee and Canal Backfill	X	P	CERP degrades ~24 miles with backfill vs. CEPP degrades ~ 8 miles without canal backfill
(QQ) Remove L-28 & L-28 Interim levees and Canal Backfill	X		
(QQ) Construct 8 passive weirs along (~6?4 (north of MWD/CERP S-345's)	X		
(QQ) Backfill L-67A Canal from Tamiami Trail (~2.5 miles north)	X		
(QQ) Relocate a single MWD S-349 structure (within L-67A Canal)	X		
(QQ) Remove S-344, S-343 (A&B) and S-12s (A thru D)	X		
(SS) Relocate Miami-Dade Water Supply Deliveries/North New River Mods	X		CEPP/Decomp analysis concluded that NNR Canal mods are not required for WCA 3A Miami Canal backfill
New S-333N Structure just north of existing S-333		X	
New S-356W divide structure at the L-29 Canal		X	
New L-67D Levee (~6.5 miles) L-67A to L-28		X	
Old Tamiami Trail Removal		X	CERP assumed removal with MWD
Removal L-67 Extension levee and Canal Backfill		X	CERP assumed removal with MWD, CEPP removes ~ 5.5 miles of the remaining levee
EWP/L-31N Seepage Management and S-356 Structures (U, V with pilot project, and FF)			
(U) Bird Drive Basin Recharge Area Reservoir (11.5 kaf)	X		
(V) Seepage Barrier (Cutoff) Wall	X	P	CERP Pilot Project seepage barrier wall assumed between S-334 and S-335 (~ 1.7 miles), length of L31N Seepage Management is unclear.
(V) Seepage Groundwater Wells	X		
(FF) Remove MWD S-356 Pump Station	X	X	
(FF) Relocate MWD S-357 Pump Station	X		CERP S-357 location proposed to discharge into ENP (different than MWD 2000 CFS)
(FF) Add New S-356 A & B Pump Stations (900 cfs) each	X	P	CERP Adding 2 S-356 (900 cfs) structures vs CEPP Adding 1 S-356 (1000 cfs)
(FF) Relocate L-31N Borrow Canal	X		
(H) Everglades Rain-Driven Operations	X	X	

CEPP FEATURES as "P" for Partial CERP Infrastructure and "X" is full CERP

Table B-10

B.1.1 FINAL ARRAY OF ALTERNATIVES/SUMMARY OF COST

Optimized components from the screening of treatment and storage, distribution and conveyance and the resulting seepage management measures were combined into a limited final array of alternatives to undergo a detailed evaluation. Operational optimization in the form of Everglades' rain-driven operations was utilized for the development of the Final Array of Alternatives. Evaluation of the Final Array was conducted utilizing hydrologic models. These ecological Performance Measures were developed from (restoration, coordination and verification) RECOVER Conceptual Ecological Models (CEM) and approved by RECOVER. RECOVER is responsible for establishing the system wide ecological goals for the central & southern Florida ecosystem.

B.1.1.1 ALTERNATIVE 1

For Storage and Treatment Alternative 1 included A-2 Flow Equalization Basin (FEB) integrated with state remedies Flow Equalization Basin on A-1 and will utilize Hydropattern Restoration Feature: spreader canal 3 miles west of S-8. It will also include backfilling the Miami canal from 1 mile south of S-8 to I-75 and the L-28 triangle-gap levee for distribution and conveyance. Alternative 1 would also increase the S-333 capacity to 3000 cfs have (1) 750 cfs gated structure in L-67 A, (1) 6000-ft gap in L67-C levee, Tamiami trail western 2.6 mile and eastern 1 mile bridge, L-29 canal max stage at 9.7 el., and degrading of the southern 1.5 mile L-67 extension. Alternative 1 also includes expanding S-356 to 1000 cfs, (2) 250 cfs pumps on L-31N to return seepage, G-211 flood control operations if needed and the utilization of coastal canal to convey seepage.

B.1.1.2 ALTERNATIVE 2

For Storage and Treatment Alternative 2 included A-2 Flow Equalization Basin integrated with state remedies Flow Equalization Basin on A-1 and will utilize Hydropattern Restoration Feature: spreader canal 3 miles east & west of S-8 and 1.5 mile 400 cfs spreader canal east of G-206. It will also include backfilling the Miami canal from S-8 to I-75. Alternative 2 would also increase the S-333 capacity to 3000 cfs have (1) 750 cfs and (2) 500 cfs gated structures in L-67 A, (1) 6000-ft gap in L67-C levee at each structure, and additional 500 cfs gravity structure out of WCA-3B. Tamiami trail western 2.6 mile and eastern 1 mile bridge, L-29 canal max stage at 9.7 el., and degrading of the L-67 extension. For seepage management control this alternative increases S-356 to 1000 cfs, creates a full depth penetrating seepage barrier from S-335 to S-334 with a partial seepage barrier south of Tamiami Trail 2 miles along L-31N, (1) 250 cfs pump on L-31N into ENP while using G-211 for limited water use only.

B.1.1.3 ALTERNATIVE 3

For Storage and Treatment Alternative 3 included A-2 Flow Equalization Basin integrated with state remedies Flow Equalization Basin on A-1 and will utilize Hydropattern Restoration Feature: spreader canal 3 miles east & west of S-8 and 1.5 mile 400 cfs spreader canal east of G-206. It will also include backfilling the Miami canal from S-8 to I-75. Alternative 3 would also increase the S-333 capacity to 3000 cfs have (4) 500 cfs gated structure in the southern end of L-67 A, (1) 6000-ft gap in L67-C levee at each structure, Tamiami trail western 2.6 mile and eastern 1 mile bridge, L-29 canal max stage at 9.7 el., and degrading of the L-67 extension. For seepage management control this alternative increases S-356 to 1000 cfs, creates a partial depth seepage barrier south of Tamiami Trail 5 miles along L-31N, full depth penetrating seepage barrier from S-335 to S-334 G-211 for limited water use only.

B.1.1.4 ALTERNATIVE 4

For Storage and Treatment Alternative 4 included A-2 Flow Equalization Basin integrated with state remedies Flow Equalization Basin on A-1 and will utilize Hydropattern Restoration Feature: spreader canal 3 miles east & west of S-8 and 1.5 mile 400 cfs spreader canal east of G-206. It will also include backfilling the Miami canal from S-8 to I-75. Alternative 4 would also increase the S-333 capacity to 3000 cfs have (2) 500 cfs gated structure in the southern end of L-67 A, an included levee in WCA 3B, degrade L-67C levee in Blue Shanty Flow way, (1) 500 cfs gated structure north of the blue shanty levee and (1) 6000-ft gap in L67-C levee, Tamiami trail western 2.6 mile and eastern 1 mile bridge, L-29 canal max stage at 9.7 el., and degrading of the southern 1.5 mile portion of L-67 extension levee. For seepage management control this alternative increases S-356 to 1000 cfs, creates a partial depth seepage barrier south of Tamiami Trail 5 miles along L-31N, G-211 used in flood control operations and utilizing coastal canals.

B.1.2 RECOMMENDED PLAN

The Recommended Plan was chosen by the Project Delivery Team (PDT) according to Cost Effectiveness/Incremental Cost Analysis procedures and resulted directly from the plan formulation described above. The Economics Appendix fully describes the plan selection. The scope of work for the Recommended Plan is found in Appendix A, Engineering. The MCACES/MII cost estimate for the Recommended Plan (Section B3, below) is based on that scope and is formatted in the Civil Works Work Breakdown Structure (CWWBS). The notes provided in the body of the estimate detail the estimate parameters and assumptions. These include pricing at the Fiscal Year 2013 price level (1 October 2012-30 September 2013). For project justification purposes, the estimate costs are categorized under the appropriate CWWBS code and include both construction and non-construction costs.

The construction costs fall under the following feature codes:

- 02 Relocations
- 03 Reservoirs
- 08 Roads, Railroads, and Bridges
- 09 Channels and Canals
- 11 Channels and Canals
- 13 Pumping Plant
- 14 Recreation Facilities
- 15 Floodway Control-Diversion Structures
- 16 Bank Stabilization

The non-construction costs fall under the following feature codes:

- 01 Lands and Damages
- 30 Planning, Engineering and Design
- 31 Construction Management

B.1.2.1 CONSTRUCTION COST

For the construction costs, unit prices for heavy construction related work were developed in the Parametric cost tool then verified by the USACE cost spreadsheet/database and then entered into MCACES/MII. The spreadsheet, database and MCACES/MII documents have been internally reviewed and were sent to the MCX for the ATR review. These costs include all major project components categorized under the appropriate CWWBS to the sub-feature level. The Total Project Cost Summary (TPCS) on the Recommended Plan contains contingencies as noted in the estimate (below) and were determined as a result of the risk analysis.

B.1.2.2 NON-CONSTRUCTION COST

Non-construction costs typically include Lands and Damages (Real Estate), Planning/Pre-Construction Engineering & Design (PED), Engineering During Construction (EDC) and Construction Management Costs (Supervision & Administration, S&A). These costs were provided by the PDT either as a lump sum cost or as a percentage of the total Construction Contract Cost. Lands and Damages are provided by Real Estate and are best described in the Real Estate Appendix, Appendix D. PED costs are for the preparation of contract plans and specifications (P&S) and include itemized costs that were provided by the PDT, as well as percentages for Engineering During Construction (EDC) that were provided by the project manager. Construction Management costs are for the supervision and administration of a contract and include Project Management and Contract Admin costs. These costs were provided by the project manager and are included as a percentage of the total construction contract cost.

The main report details both cost allocation and cost apportionment for the Federal Government and the Non-Federal Sponsor. Also included in the main report are the Non-Federal Sponsor's obligations (items of local cooperation).

B.1.3 PLAN FORMULATION COST ESTIMATES

For the plan formulation cost estimates, unit prices for heavy construction related activities work were developed in the parametric costing tool. Unit prices for the remaining major or variable construction elements were also developed in MCACES/MII based on input from the PDT. Design details, information and assumptions were provided in the Engineering Appendix. Plan formulation alternatives were run through the parametric costing tool for calculation of quantities. Cost Engineering provided estimates for the initial construction on all alternatives that were input into the parametric costing tool. An abbreviated risk analysis was done to establish the contingency for each of the alternatives. The possibility that a particular feature may indeed not be built, or that its capacity or configuration may indeed be radically altered, is not within the scope of cost risk analysis. The range estimates are based on the scope of work presented with limited design information. The design variances assumed for the cost risk analysis are not within a range that would perceive to change the fundamental nature of the component feature; however, within any project for which design is limited there will be a higher rate at which the contingency will be applied. These factors are largely into play when a project is in its planning phase. As with most risks, mitigating factors such as a more detailed design will reduce these risks and therefore, reduce the contingency. The design data itself cannot be taken as exact. From the standpoint of cost, it must be assumed that a design specific such as levee length is, in actuality, the most probable value

of a range of values. The cost estimates rely on assumed values for criteria essential for the estimate, but for which there is limited or no engineering data. It should be noted that even with risk mitigation cost should not be swayed. As the design increases with detail, costs go up but the contingency percentage goes down. Costs should be balanced once this takes effect.

B.1.4 CONSTRUCTION SCHEDULE

A construction schedule has been produced by the Cost MCX and is included in the draft report by utilizing input from the PDT and reflects all project construction components. The schedule considers not only durations of individual components of construction, but also the timing of construction contracts based on funding and construction windows. The construction schedule was combined with the project schedule to create an overall schedule that will be used for the generation of the Total Project Cost Summary (TPCS). The construction schedule will change as the project moves through the various project lifecycle phases.

B.1.5 TOTAL PROJECT COST SUMMARY

The cost estimate for the Recommended Plan is prepared with an identified price level date and inflation factors are used to adjust the pricing to the project schedule. This estimate is known as the Fully Funded Cost Estimate or Total Project Cost Summary. It includes all Federal and Non-Federal costs: Lands, Easements, Rights of Way and Relocations; construction features; Preconstruction Engineering and Design; Engineering during Construction, Construction Management; Contingency; and Inflation.

B.1.6 CONSTRUCTION COST ESTIMATE

A MII cost estimate was produced by the Cost MCX, in the Walla Walla district, and is included in the draft PIR. The estimate was produced using labor, material, equipment and site specific information obtained from the non-federal sponsor. The estimate is based on the engineering appendix and the assumptions and quantity take offs document. The assumptions and quantity take offs document was produced in collaboration with the non-federal sponsor, SFWMD. Non-construction costs were included as percentages of the total construction contract cost including; Planning, Engineering and Design, Engineering during Construction, Construction Management, supervision and administration and Lands and Damages. There were two rounds of cost and schedule risk assessment that were used to develop the contingency applied to the estimate. This was developed by the Cost MCX in Walla Walla using the Oracle Crystal Ball Software and the Monte Carlo model. A construction schedule and TPCS was also developed by the Cost MCX.

The MII cost estimate will be refined further after initial release in the draft report. Once all reviews and comments have been addressed, the estimate and other supporting products will be adjusted to account for any changes that affect cost and schedule. After the final estimate is produced, it will undergo cost certification for inclusion in the final report.

B.2 PLAN FORMULATION COST ESTIMATES

TABLE B.2

	SUMMARY OF COSTS FOR CEPP ALTERNATIVE PLANS*			
	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Cost Component				
Construction Features	**$1,855,000,000**	**$2,174,000,000**	**$2,282,000,000**	**$2,147,000,000**
Lands	**$74,000,000**	**$70,000,000**	**$70,000,000**	**$70,000,000**
Total First Cost	**$1,929,000,000**	**$2,244,000,000**	**$2,352,000,000**	**$2,217,000,000**
Interest During Construction				
Construction	$103,000,000	$121,000,000	$127,000,000	$119,000,000
Lands	$8,000,000	$7,000,000	$7,000,000	$7,000,000
Total Interest During Construction	**$111,000,000**	**$128,000,000**	**$134,000,000**	**$126,000,000**
Total Project Investment	**$2,040,000,000**	**$2,372,000,000**	**$2,486,000,000**	**$2,343,000,000**
Average Annual Cost				
Interest & Amortization	$118,900,000	$138,300,000	$144,900,000	$136,600,000
Operation, Maintenance, Repair, Rehabilitation, and Replacement	$5,500,000	$6,400,000	$6,900,000	$6,500,000
Average Annual Cost	**$124,400,000**	**$144,700,000**	**$151,800,000**	**$143,100,000**

* NER Annual costs are based on a 28-year period of analysis. Costs do not include costs of recreation features.
*Costs are planning level costs and do not coincide exactly with the detailed costs of the recommended plan presented in other sections of the report. Computation of the detailed estimate for the recommended plan will be based on additional engineering and design.

B.3 RECOMMENDED PLAN COST ESTIMATE

Please see the following pages for the cost broken down by features.

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Title Page

This estimate is a Class 3 - Baseline (Feasibility/DPR/LRR) based on Engineering Appendix Dated June 2013. With updated scope assumptions based on the PDT dated 07-15-2013.

Estimated by Walla Walla District
Designed by Jacksonville District USACE
Prepared by Amro Habib
Preparation Date 3/12/2014
Effective Date of Pricing 10/1/2013
Estimated Construction Time 4,466 Days
This report is not copyrighted, but the information contained herein is For Official Use Only

Labor ID: FLJ30032 EQ ID: EP11R03 | Currency in US dollars | TRACES MII Version 4.2

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CEPP CEPP Recommended Plan 1

FEB North of the Red Line - Storage and Treatment Flow Equalization Basin (FEB) A-2 1

S-623 S-623 [15] -- Gated Spillway 3700 CFS in STA 3/4 Canal 1
S-624 S-624 [15] -- Gated Sag Culverts (FEB inflow structure) 1550 CFS on STA 3/4 Supply Canal 1
S-625 S-625 [15] -- Gated Culverts (FEB discharge structure) 1550 CFS Discharge structure in FEB Perimeter 1
S-626 S-626 [13] -- Seepage Pump Station 700 CFS West Side of Seepage Canal C-626 1
S-627 S-627 [15] -- Emergency Overflow Weir 445 CFS Between A-2 and A-1 FEB just North of S-628 1
S-628 S-628 [15] -- Gated Culvert FEB Intake / Discharge Structure 930 CFS Between A-2 and A-1 FEB 1
L-624 L-624 [11] -- Levee FEB Perimeter Levee 1
L-625 L-625 [11] -- Levee FEB Interior Inflow Canal Levee 1
C-624 C-624 [09] -- Inflow Canal 1550 CFS West Side of FEB 1
C-624E C-624E [09] -- Spreader Canal Northern Boundary of FEB 1
C-625E C-625E [09] -- Collection Canal 400 CFS FEB Interior Collection Canal Along Southern Perimeter 1
C-625W C-625W [09] -- Outflow Canal 1550 CFS FEB Exterior Outflow; between S-625 and G-372 HW 1
C-626 C-626 [09] -- Seepage Canal 400 CFS West and Northern Exterior Perimeter of FEB 1

SRL South of the Red Line - Diversion & Conveyance 1

S-620 S-620 [15] -- Gated Culvert 500 CFS In L-6 Canal 1
S-621 S-621 [15] -- Gated Spillway 2500 CFS On STA 3/4 Outflow Canal 1
S-622 S-622 [15] -- Gated Spillway 500 CFS In L-5 Canal 1
New (S-8A) PS New (S-8A) PS [09/15] -- Gated Culverts w. Canal 3080 and 1020 CFS In Miami and L-4 Canal 1
S-630 S-630 [13] -- Pump Station 360 CFS in L-4 Canal 1
L-4 Levee L-4 Levee [11] -- Levee Removal L-4 Interior Levee 1
Miami Canal Miami Canal [09] -- Miami Canal Backfill 1
Tree Islands Tree Islands [09] -- Mounds Miami Canal 1
L-5 East L-5 East [09] -- Canal 500 CFS Remnant L-5 Canal East 1
L-5 West L-5 West [09] -- Canal 3000 CFS L-5 Canal West 1

Labor ID: FL130032 EQ ID: EP11R03 Currency in US dollars TRACES MII Version 4.7

BGY Blue Green Yellow Line - Distribution, Conveyance and Seepage Management 1

S-333 (N) S-333 (N) [09/15] -- Gated Spillway w/ New Canal 1150 CFS Just North of Existing S-333 1
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S-631 S-631 [15] -- Gated Culvert 500 CFS in L-67A 1
S-632 S-632 [15] -- Gated Culvert 500 CFS in L-67A 1
S-633 S-633 [15] -- Gated Culvert 500 CFS in L-67A 2
L-67C Gap L-67C Gap [11] -- Levee Removal Gap In L-67C 2
L-67D L-67D [11] -- New Levee In WCA 3B 2
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L-29 L-29 [11] -- Levee Removal in L-29 Levee 2
Remove TT Remove TT [11] -- Road Removal Old Tamiami Trail (From L-67 Ext West to ENP Tram Rd) 2
L-67 EXT L-67 EXT [11] -- Levee Removal and Canal Backfill in L-67 Ext Levee 2
L-31N L-31N [11] -- Seepage Barrier Cutoff Wall In L-31N Levee just South of Tamiami Trail 2
S-346 S-346 [15] -- 2-72 2
L-67A Spoils L-67A Spoils [11] -- L-67A Spoil Mounds in the Vicinity of S-631, 632 and 633 2

REC Recreation 2

REC.FEB L-624 [14] -- Recreation FEB 2
REC.SRL [14] -- Recreation North of the Red Line 2
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06 Fish & Wildlife 2

AM & BO 2

Cultural Resource Preservation 2

Cultural Resources 2

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Library Properties Page 1

Designed by
Jacksonville District USACE
Estimated by
Walla Walla District
Prepared by
Amro Habib

Design Document: Engineering Appendix : Appendix A and Annexes
Document Date: 3/12/2014
District: Jacksonville District
Contact: Amro Habib
Budget Year: 2014
UOM System: Original

Direct Costs
LaborCost
EQCost
MatlCost
SubBidCost
UserCost1

Timeline/Currency
Preparation Date: 3/12/2014
Escalation Date: 10/1/2013
Eff. Pricing Date: 10/1/2013
Estimated Duration: 4406 Day(s)

Currency: US dollars
Exchange Rate: 1.000000

Costbook CB12EB-b: MII English Cost Book 2012-b

Labor FL130032: Florida Labor Rates
Note: This estimate uses Department of Labor Statistics for South Florida Dated May 2012.
Davis Bacon labor rates for Palm Beach county FL130032 dated 04/05/2013 and Wage determination No.: 2005-2112 dated 06/13/2012

Labor Rates
LaborCost1
LaborCost2
LaborCost3
LaborCost4

Equipment EP11R03: MII Equipment 2011 Region 03
Note: Fuel Prices updated from EIA.gov dated 6/3/2013 for Gulf Coast Area. assumed 85% cost of on road diesel for off road.

03 SOUTHEAST

Sales Tax	8.35
Working Hours per Year	1,530
Labor Adjustment Factor	0.86
Cost of Money	2.13
Cost of Money Discount	25.00
Tire Recap Cost Factor	1.50
Tire Recap Wear Factor	1.80
Tire Repair Factor	0.15
Equipment Cost Factor	1.00
Standby Depreciation Factor	0.50

Fuel

Electricity	0.087
Gas	3.413
Diesel Off-Road	3.205
Diesel On-Road	3.770

Shipping Rates

Over 0 CWT	15.58
Over 240 CWT	14.19
Over 390 CWT	12.14
Over 490 CWT	10.20
Over 590 CWT	8.13
Over 790 CWT	8.13
Over 890 CWT	0.25

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Project Notes Page: 1

Date	Author	Note
6/5/2013 8:35:02 AM	NWW	*PROJECT DESCRIPTION*

The study area for the Central Everglades Planning Project (CEPP) encompasses the Northern Estuaries (St. Lucie River and Indian River Lagoon and the Caloosahatchee River and Estuary), Lake Okeechobee, a portion of the EAA, the Water Conservation Areas (WCAs), Everglades National Park (ENP), the Southern Estuaries (Florida Bay and Biscayne Bay), and the Lower East Coast. The purpose of CEPP is to improve the quantity, quality, timing and distribution of water flows to the Central Everglades.

The recommended plan will provide approximately 200,000 ac-ft per year of additional water flow to the Everglades by redirecting through the EAA water which is currently being discharged to tide via the St. Lucie and Caloosahatchee Estuaries and providing FEB storage to attenuate flow rates, prior to water quality treatment using available, off-peak capacity of the state-operated STA-2 and STA-3/4. Following water quality treatment, this additional flow quantity will be re-distributed as inflows to WCA 2A and WCA 3A, and the recommended plan features will modify the quantity, quality, timing, and spatial distribution of flows into and through WCA 3A, WCA 3B, and ENP to Florida Bay in order to meet the project objectives. This plan would be accomplished by a combination of modifications to the existing Central and South Florida project components, construction of additional components, and modifications to current approved water control manuals. Several proposed or existing levees, canals, and culverts, and pump stations would be constructed, modified, or removed to improve the flow of water through the system as the first increment of CEPP.

The recommended plan includes features in three major studied areas: North of the Redline, South of the Redline, and along Blue-Green-Yellow-Line.

Features in the EAA (North of the Redline) include construction of the 14,000 acre A-2 FEB (L-624 perimeter levee and L-625 interior levee; C-624, C-624E, C-626 internal distribution channels; S-623, S-624, S-628 inlet structures; S-625 outlet structures, and C-625E, C-625W canals and channels connecting the FEB to the Miami Canal).

Conveyance features in WCA 2A and northern WCA 3A (South of the Redline) include: S-620 a gated culvert to deliver water from the L-6 Canal to the remnant L-5 Canal, S-622 a new gated spillway to deliver water from the remnant L-5 canal to the western L-5 canal (during L-6 diversion operations), S-621 a new gated spillway to deliver water from STA 3/4 to the S-7 pump station during peak discharge events (eastern flow route is not typically used during normal operations, including L-6 diversion operations, enlarge approximately 13.6 miles of the L-5 Canal, degrade approximately 2.9 miles of the southern L-4 Levee along the northwest boundary of WCA-3A, S-630 a 360 cfs pump station to maintain Seminole Tribe water supply deliveries west of the L-4 Canal; S-8A new gated culverts to deliver water from the Miami Canal (downstream of S-8, which pulls water from the L-5 Canal) to the L-4 Canal, and backfill approximately 13.5 miles of the Miami Canal and include upland mounds between a point approximately 1.5 miles south of the S-8 pump station and Interstate Highway I-75.

Additional conveyance features that would be located in southern WCA 3A, WCA 3B, and the northern edge of ENP (Blue Green Yellow line) include: S-333N a 1,150 cfs gated spillway adjacent to S-333; S-631 a 500 cfs gated culvert in L-67A Levee and an associated 6,000 foot gap in the L-67C Levee, a flow way through the western end of WCA 3B (S-632 and S-633 2 gated culverts in L-67A Levee, removal of approximately 8 miles of L-67C Levee, removal of approximately 4.3 miles of L-29 Levee, construct L-67D a new approximately 8.5 mile levee); S-355W a gated spillway in the L-29 Canal to maintain water deliveries in the L-29 Canal to the eastern Modified Water Deliveries (MWD) 1-mile bridge and maintain western access to the L-29 Levee, remove approximately 5.5 miles of the L-67 Extension Levee, remove approximately 6 miles of Old Tamiami Trail between the Everglades National Park (ENP) Tram Road and the L-67 Extension Levee, S-356 a new 1,000 cfs pump station to replace the existing temporary S-356 pump station and a ~4.2 mile long, 35 foot deep tapering seepage barrier cutoff wall along the L-31N Levee just south of Tamiami Trail. Work in this area also includes removal of spoil along the western L-67A canal in the vicinity of the new control.

Labor ID: FL130032 EQ ID: EPLIR03 Currency in US dollars TRACES MII Version 4.2

Date Author Note

structures and removal of vegetation along WCA-3B agricultural ditches.

BASIS OF DESIGN

This estimate is a Class 3 - Baseline (Feasibility/DPR/LRR) based on Engineering Appendix Dated June 2013. With updated scope assumptions based on the PDT dated 07-15-2013.

ACQUISITION PLAN

The project will be acquired by the Bidding process.

This work will not be performed by a Contractor under the Small Business Administration 8a program.

This estimate acknowledges no Amendments.

Prices are good for the period FY 2013.

SUB-CONTRACTING PLAN

It is assumed that the Prime Contractor will perform associated with either earthwork or concrete work dependant on the structure type. A general Subcontractor will be assigned for the remaining work. Sub contracting is currently considered at 35% of the total project.

PROJECT CONSTRUCTION

SITE ACCESS

The A-2 FEB is located West of Highway 27, north of the STA-3/4 canal and east of the Miami Canal. It is adjacent to the Northwest corner of the A-1 FEB.

The south of redline work area is along the L-5 canal east from the intersection of the L-6 canal west to the L-28 canal North of Interstate 75.

The Blue Green Yellow area is located along Highway 90 and throughout WCA 3A and 3B.

BORROW and MATERIAL PROCESSING AREAS

Date Author Note

When possible all material for the construction will use onsite borrow. If needed additional material will be commercially supplied. All material not used onsite will be removed from site and disposed of in a legal manor.

Borrow and Material Processing in the FEB is assumed to be setup and operated at a central location inside the FEB perimeter. (26°27'41.97"N, 80°44'30.24"W)

Borrow and Material Processing for the South of Redline area is assumed to be setup and operated directly southeast of the existing S-8 Pump Station (26°19'53.18"N, 80°46'24.75"W)

Borrow and Material Processing for the Blue Green Yellow area will be setup north of the existing S-333 gated structure. (25°45'53.40"N, 80°40'23.33"W)

CONSTRUCTION METHODOLOGY

The construction methodology is standard.

UNUSUAL CONDITION (Soil, Water, Weather)
Care and diversion of water requires use of cofferdams around excavations as the water table is at or near the natural ground surface. This ground water will require the use of dewatering pumps or other means to prevent water infiltration. Some construction will be conducted in the wet and will not require extensive dewatering. It is assumed that the soil is composed of layers of organic material on the surface followed in some areas with common reusable soils. Below these 1-2 layers a layer of loose rippable limestone rock and below that is hard limestone which will require blasting in order to allow for excavation.

UNIQUE TECHNIQUES OF CONSTRUCTION
It is assumed that unique techniques of construction will not be required.

CONSTRUCTION WINDOWS

SCHEDULE

The schedule for construction has not been defined at this point in the project. It is assumed from previous contracts in the area that there will be a total of 73 anticipated weather delay work days based on a 5-day work week. These work days account for an assumed 90% productivity impact.

OVERTIME

This estimate contains overtime to complete the project. It is assumed that there will be 10% overtime to account for the 73 anticipated weather delay days in a year.

Date	Author	Note
		EQUIPMENT AND LABOR AVAILABILITY & DISTANCE TRAVELED
		This estimate uses Department of Labor Statistics for South Florida Dated May 2012. Davis Bacon labor rates for Palm Beach county FL130032 dated 04/05/2013 and Wage determination No.: 2005-2112 dated 06/13/2012. Equipment rates used are from EP 1110-1-8, Volume 03, August 2011.
		ENVIRONMENTAL CONCERNS
		This estimate has no provisions for Monthly Anticipated Adverse Weather Delays as specified in the contract clauses.
6/11/2013 7:17:41 AM	SCOPE	Please Reference Attached PDF document for all scope assumptions and take off.
		Document: CEPP Cost Estimate Quantity Takeoff.pdf

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Project Cost Summary Report Page 1

Description	Quantity	UOM	ContractCost	Escalation	Contingency	SIOH	ProjectCost
Project Cost Summary Report			947,231,700	0	0	0	947,231,700
CEPP CEPP Recommended Plan	1	LS	947,231,700	0	0	0	947,231,700
FEB North of the Red Line - Storage and Treatment Flow Equalization Basin (FEB) A-2	1	LS	373,617,065	0	0	0	373,617,065
S-623 S-623 [15] -- Gated Spillway 3700 CFS in STA 3/4 Canal	1	LS	21,549,177	0	0	0	21,549,177
S-624 S-624 [15] -- Gated Sag Culverts (FEB inflow structure) 1550 CFS on STA 3/4 Supply Canal	1	LS	23,773,583	0	0	0	23,773,583
S-625 S-625 [15] -- Gated Culverts (FEB discharge structure) 1550 CFS Discharge structure in FEB Perimeter	1	LS	17,233,839	0	0	0	17,233,839
S-626 S-626 [13] -- Seepage Pump Station 700 CFS West Side of Seepage Canal C-626	1	LS	26,390,867	0	0	0	26,390,867
S-627 S-627 [15] -- Emergency Overflow Weir 445 CFS Between A-2 and A-1 FEB just North of S-628	1	LS	288,630	0	0	0	288,630
S-628 S-628 [15] -- Gated Culvert FEB Intake / Discharge Structure 930 CFS Between A-2 and A-1 FEB	1	LS	24,744,648	0	0	0	24,744,648
L-624 L-624 [11] -- Levee FEB Perimeter Levee	1	LS	111,131,186	0	0	0	111,131,186
L-625 L-625 [11] -- Levee FEB Interior Inflow Canal Levee	1	LS	22,623,926	0	0	0	22,623,926
C-624 C-624 [09] -- Inflow Canal 1550 CFS West Side of FEB	1	LS	8,676,277	0	0	0	8,676,277
C-624E C-624E [09] -- Spreader Canal Northern Boundary of FEB	1	LS	76,900,325	0	0	0	76,900,325
C-625E C-625E [09] -- Collection Canal 400 CFS FEB Interior Collection Canal Along Southern Perimeter	1	LS	6,299,125	0	0	0	6,299,125
C-625W C-625W [09] -- Outflow Canal 1550 CFS FEB Exterior Outflow; between S-625 and G-372 HW	1	LS	7,258,372	0	0	0	7,258,372
C-626 C-626 [09] -- Seepage Canal 400 CFS West and Northern Exterior Perimeter of FEB	1	LS	26,747,111	0	0	0	26,747,111
SRL South of the Red Line - Diversion & Conveyance	1	LS	254,723,789	0	0	0	254,723,789
S-620 S-620 [15] -- Gated Culvert 500 CFS In L-6 Canal	1	LS	10,040,965	0	0	0	10,040,965
S-621 S-621 [15] -- Gated Spillway 2500 CFS On STA 3/4 Outflow Canal	1	LS	22,205,410	0	0	0	22,205,410
S-622 S-622 [15] -- Gated Spillway 500 CFS In L-5 Canal	1	LS	13,764,260	0	0	0	13,764,260
New (S-8A) PS New (S-8A) PS [09/15] -- Gated Culverts w. Canal 3080 and 1020 CFS In Miami and L-4 Canal	1	LS	49,032,777	0	0	0	49,032,777
			30,423,949.68				*30,423,949.68*
S-630 S-630 [13] -- Pump Station 360 CFS in L-4 Canal	1	EA	30,423,950	0	0	0	30,423,950
L-4 Levee L-4 Levee [11] -- Levee Removal L-4 Interior Levee	1	LS	2,410,451	0	0	0	2,410,451
Miami Canal Miami Canal [09] -- Miami Canal Backfill	1	LS	94,138,408	0	0	0	94,138,408
Tree Islands Tree Islands [09] -- Mounds Miami Canal	1	LS	6,992,532	0	0	0	6,992,532
L-5 East L-5 East [09] -- Canal 500 CFS Remnant L-5 Canal East	1	LS	11,437,090	0	0	0	11,437,090
L-5 West L-5 West [09] -- Canal 3000 CFS L-5 Canal West	1	LS	14,277,946	0	0	0	14,277,946
BGY Blue Green Yellow Line - Distribution, Conveyance and Seepage Management	1	LS	223,869,278	0	0	0	223,869,278
S-333 (N) S-333 (N) [09/15] -- Gated Spillway w/ New Canal 1150 CFS Just North of Existing S-333	1	LS	11,493,935	0	0	0	11,493,935
New S-356 New S-356 [13] -- Pump Station 1000 CFS In Vicinity of Existing S-356	1	LS	34,993,180	0	0	0	34,993,180
S-631 S-631 [15] -- Gated Culvert 500 CFS in L-67A	1	LS	6,909,639	0	0	0	6,909,639
S-632 S-632 [15] -- Gated Culvert 500 CFS in L-67A	1	LS	6,952,948	0	0	0	6,952,948

Labor ID: FL130032 EQ ID: EP11R03 Currency in US dollars PRACES MII Version 4.2

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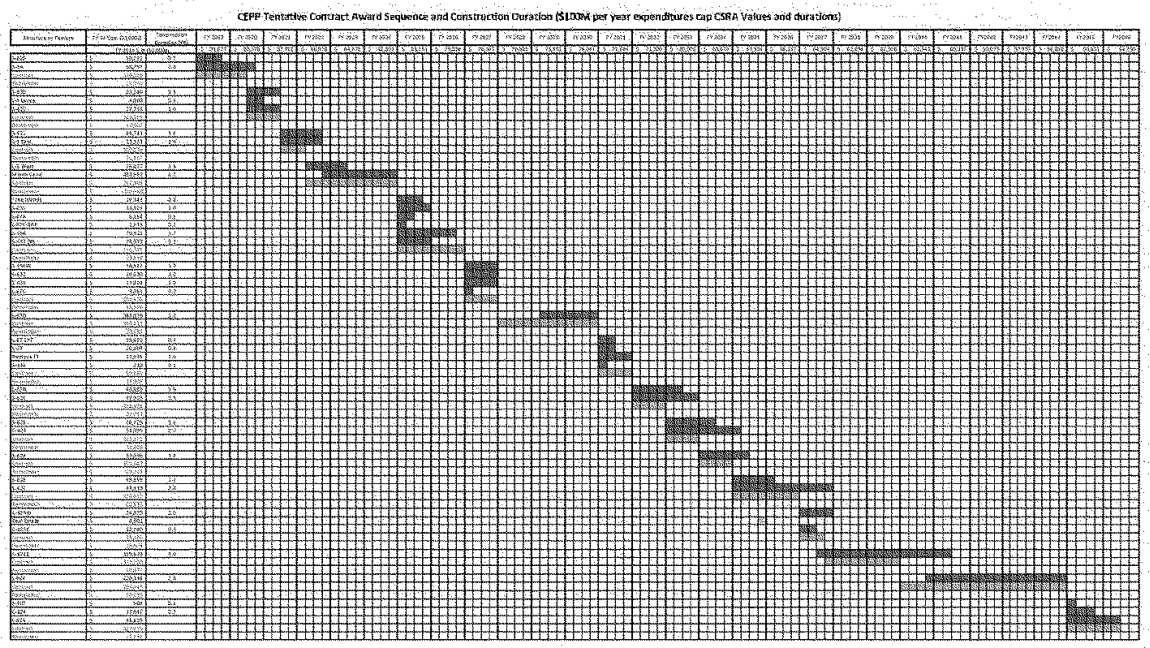
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EST Date 10/1/2013 | Project : CEPP Master 20 Feb 2014 with cont |
Project Cost Summary Report Page 2

Description	Quantity	UOM	ContractCost	Escalation	Contingency	SIOH	ProjectCost
S-633 S-633 [15] -- Gated Culvert 800 CFS in L-67A	1	LS	6,992,270	0	0	0	6,992,270
L-67C Gap L-67C Gap [11] -- Levee Removal Gap In L-67C	1	LS	799,980	0	0	0	799,980
L-67D L-67D [11] -- New Levee In WCA 3B	1	LS	82,089,120	0	0	0	82,089,120
L-67C L-67C [11] -- Levee Removal L-67C Levee	1	LS	4,489,118	0	0	0	4,489,118
S-355W S-355W [15] -- Gated Spillway 1230 CFS in L29 Canal, East of L-67D Levee Terminus and 2.6 mile Bridge	1	LS	19,081,111	0	0	0	19,081,111
L-29 L-29 [11] -- Levee Removal in L-29 Levee	1	LS	10,035,812	0	0	0	10,035,812
Remove TT Remove TT [11] -- Road Removal Old Tamiami Trail (From L-67 Ext West to ENP Tram Rd)	1	LS	5,917,835	0	0	0	5,917,835
L-67 EXT L-67 EXT [11] -- Levee Removal and Canal Backfill in L-67 Ext Levee	1	LS	9,239,181	0	0	0	9,239,181
L-31N L-31N [11] -- Seepage Barrier Cutoff Wall In L-31N Levee just South of Tamiami Trail	1	LS	21,661,172	0	0	0	21,661,172
S-346 S-346 [15] -- 2-72" metal culvert w/Flash Board Removal 165 CFS in Old Tamiami Trail	1	LS	108,154	0	0	0	108,154
			172,343.70				*172,343.70*
L-67A Spoils L-67A Spoils [11] -- L-67A Spoil Mounds in the Vicinity of S-631, 632 and 633	18	EA	3,105,823	0	0	0	3,105,823
REC Recreation	1	LS	4,440,568	0	0	0	4,440,568
REC.FEB L-624 [14] -- Recreation FEB	1	LS	1,011,789	0	0	0	1,011,789
REC.SRL [14] -- Recreation North of the Red Line	1	LS	577,490	0	0	0	577,490
REC.BGY [14] -- Recreation Blue Green Yellow Line	1	LS	2,851,290	0	0	0	2,851,290
			72,316,000.00				*72,316,000.00*
06 Fish & Wildlife	1	EA	72,516,000	0	0	0	72,516,000
			72,316,000.00				*72,316,000.00*
AM & BO	1	EA	72,516,000	0	0	0	72,516,000
			18,065,000.00				*18,065,000.00*
Cultural Resource Preservation	1	EA	18,065,000	0	0	0	18,065,000
			18,065,000.00				*18,065,000.00*
Cultural Resources	1	EA	18,065,000	0	0	0	18,065,000

Labor ID: FL130032 EQ ID: EP11R03 | Currency in US dollars | TRACES MII Version 4.2

B.4 SCHEDULE

Please see the attached for the construction schedule derived based on a $100M a year funding scenario. CEPP project construction is expected to cover more than two decades. The attached schedule considers construction contract durations, non-construction durations, monitoring and other mitigation measures.


CEPP Tentative Contract Award Sequence and Construction Duration ($100M per year expenditures cap CSRA Values and durations)

B.5 RISK AND UNCERTAINTY ANALYSIS

The Risk Analysis was conducted according to the procedures outlined in the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering MCX.
- Engineer Regulation (ER) 1110-2-1302 Civil Works Cost Engineering, dated September 15, 2008.
- Engineer Technical Letter (ETL) Construction Cost Estimating Guide for Civil Works, dated September 30, 2008.

B.5.1 RISK ANALYSIS METHODS

The risk register is a tool being used in the Pilot Planning Program as a means to identify, discuss and document issues early in the process. A risk register was developed by the study team to identify significant risks attributed to the shortened study period and to project success. In addition, a Cost and Schedule Risk Analysis was conducted specific to the project costs and schedule, that is separate from the study risk register and that results in contingency values that are applied to the project costs to set a total project cost. The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve the desired level of cost confidence. Two cost risk workshops were held to begin the process of Cost and Schedule Risk Analysis. The entire PDT participated in a risk analysis brainstorming session to identify risks associated with the recommended plan. The risks were listed in the risk register, which is a tool commonly used in project planning and risk analysis, and evaluated by the PDT. The actual Risk Register is provided. Assumptions were made as to the likelihood and impact of each risk item, as well as the probability of occurrence and magnitude of the impact if it were to occur. Separate risk models are also being developed for the initial construction and other co-main events using the Oracle Crystal Ball Risk Analysis software using the Monte Carlo Model in order to develop contingencies to apply to the project cost. The models were structured based on the CWWBS for the project and provide a contingency for each of the feature codes. Risks were evaluated for the following features of work:

- 01 Lands and Damages
- 02 Relocations
- 03 Reservoirs
- 08 Roads, Railroads, and Bridges
- 09 Channels and Canals
- 11 Channels and Canals
- 13 Pumping Plant
- 14 Recreation Facilities
- 15 Floodway Control-Diversion Structures
- 16 Bank Stabilization
- 30 Planning, Engineering and Design
- 31 Construction Management
- 32 HTRW

After the Risk models were run, the results were reviewed and all parameters were re-evaluated by the PDT as a sanity check of assumptions and inputs. Adjustments were made to the analyses accordingly and the final contingencies were established. The contingencies were applied to the recommended plan estimate in the Total Project Cost Summary in order to obtain the Fully Funded Cost.

B.5.2 RISK ANALYSIS RESULTS

Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation.

Risk Determination For Alternatives Estimates: An abbreviated Cost and Schedule Risk Analysis method was applied to determine contingencies for the alternatives estimates. To iterate, the amount of design information, when limited, directly correlates with higher than average contingency percentages. Please see attachment A for the results of the Risk Analysis.

B.6 TOTAL PROJECT COST SUMMARY

The Total Project Cost Summary (TPCS) addresses inflation through project completion (accomplished by escalation to mid-point of construction per ER 1110-2-1302, Appendix C, and Page C-2). It is based on the scope of the Recommended Plan and the official project schedule. The TPCS includes Federal and Non-Federal costs for Lands and Damages, all construction features, PED, S&A, along with the appropriate contingencies and escalation associated with each of these activities. The TPCS is formatted according to the CWWBS and uses Civil Works Construction Cost Indexing System (CWCCIS) factors for escalation (EM 1110-2-1304) of construction costs and Office of Management and Budget (EC 11-2-18X, 20 Flow Equalization Basin 2008) factors for escalation of PED and S&A costs.

The Total Project Cost Summary was prepared using the MCACES/MII cost estimate on the Recommended Plan, as well as the contingencies set by the risk analysis and the official project schedule.

B.6.1 Total Project Cost Summary Spreadsheet

Refer to the Total Project Cost Summary on the next page.

Total Project Cost Summary

Project: **Central Everglades Planning Project - P2 # 370939** Report Type: **LPP** Authority: **CG**

Location: Central and Southern Florida Contingency Development: Crystal Ball TPCS Preparation Date: 25-Feb-14

District: SAJ-Jacksonville District CWCCIS Issue: **9/1/2013** Program Year: 2014

POC: Tracy Leeser

Scope Synopsis: The recommended plan will provide approximately 200,000 ac-ft per year of additional water flow to the Everglades by redirecting through the EAA water which is currently being discharged to tide via the St. Lucie and Caloosahatchee Estuaries and providing FEB storage to attenuate flow rates, prior to water quality treatment using available, off peak capacity of the state operated STA-2 and STA-3/4. Following water quality treatment, this additional flow quantity will be re-distributed as inflows to WCA 2A and WCA 3A, and the recommended plan features will modify the quantity, quality, timing, and spatial distribution of flows into and through WCA 3A, WCA 3B, and ENP to Florida Bay in order to meet the project objectives. This plan would be accomplished by a combination of modifications to the existing Central and South Florida project components, construction of additional components, and modifications to current approved water control manuals. Several proposed or existing levees, canals, and culverts, and pump stations would be constructed, modified, or removed to improve the flow of water through the system.

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				TOTAL PROJECT COST (FULLY FUNDED)			
Civil Works		Base Based				Program Price Level Date: 2014-1Q							
WBS	Feature Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
06	FISH & WILDLIFE FACILITIES	72,516	31,907	44%	104,423	1%	73,423	32,309	105,732	42%	104,076	45,793	149,869
09	CHANNELS & CANALS	252,726	111,199	44%	363,925	2%	257,235	113,183	370,418	40%	359,257	158,073	517,330
11	LEVEES & FLOODWALLS	278,508	120,342	44%	398,846	1%	277,277	122,002	399,279	55%	430,461	189,403	619,864
13	PUMPING PLANT	91,808	40,396	44%	132,204	1%	92,624	40,754	133,378	28%	118,678	52,218	170,896
14	RECREATION FACILITIES	4,440	1,954	44%	6,394	1%	4,479	1,971	6,450	37%	6,158	2,710	8,868
15	FLOODWAY CONTROL & DIVERSION STRUC	234,173	103,036	44%	337,209	1%	237,122	104,334	341,455	29%	306,864	135,020	441,884
18	CULTURAL RESOURCE PRESERVATION	18,065	7,949	44%	26,014	1%	18,226	8,019	26,245	42%	25,832	11,366	37,198
	SUB	947,232	416,782	44%	1,364,014	1%	960,392	422,572	1,382,965	41%	1,351,327	594,584	1,945,910
01	LANDS AND DAMAGES	35,328	1,314	4%	36,642		35,328	1,314	36,642	4%	36,842	1,980	38,823
	SUB	35,328	1,314	4%	36,642		35,328	1,314	36,642	4%	36,842	1,980	38,822
30	PLANNING ENGINEERING AND DESIGN	235,579	103,655	44%	339,234	2%	239,706	105,471	345,177	113%	511,128	224,896	736,024
	SUB	235,579	103,655	44%	339,234	2%	239,706	105,471	345,177	113%	511,128	224,896	736,024
31	CONSTRUCTION MANAGEMENT	91,845	40,412	44%	132,257	2%	93,454	41,120	134,574	140%	224,324	98,703	323,027
	SUB	91,845	40,412	44%	132,257	2%	93,454	41,120	134,574	140%	224,324	98,703	323,027
32	HTRW	625	275	44%	900	1%	633	278	911	42%	897	395	1,292
	SUB	625	275	44%	900	1%	633	278	911	42%	897	395	1,292
	Totals	1,310,609	562,438	43%	1,873,047	1%	1,329,513	570,756	1,900,269	60%	2,124,517	920,558	3,045,075

Project: *Central Everglades Planning Project - P2 # 370939* 25-Feb-14

CHIEF, COST ENGINEERING
PROJECT MANAGER
CHIEF, REAL ESTATE
CHIEF, PLANNING
CHIEF, ENGINEERING
CHIEF, OPERATIONS
CHIEF, CONSTRUCTION
CHIEF, CONTRACTING
CHIEF, PM-PB
CHIEF, DPM

Estimated Federal Cost:	50%	1,522,537
Estimated Non-Federal Cost:	50%	1,522,537
Estimated Total Project Cost:		3,045,075

Spent Cost as of:	Cost ($K)	Contingency ($K)	Totals ($K)
Project First Cost for Report:	$1,329,513	$570,736	$1,900,249
Total Project Cost used to provide Sponsor information:	$2,124,517	$920,558	$3,045,075

Project: *Central Everglades Planning Project - P2 # 370939*

25-Feb-14

B.7 COST DX TPCS CERTIFICATION

The Recommended Plan estimate as well as the Cost and Schedule Risk Analysis and Total Project Cost Summary have undergone Cost Review and Certification by the Walla Walla Mandatory Center of Expertise. Certification is attached.

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

SAJ - PN 370939
Central Everglades Planning Project
Central and Southern, Florida

The Central Everglades Planning Project (CEPP), as presented by the Jacksonville District, has undergone a successful Cost Agency Technical Review (Cost ATR) of remaining costs, performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the cost products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of March 14, 2014, the Cost MCX certifies the estimated total project cost:

FY2014 First Costs:	$1,900,269,000
Fully Funded Costs:	$3,045,075,000

Note: It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management throughout the life of the project.

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Kim C. Callan, PE, CCE, PM
Chief, Cost Engineering MCX
Walla Walla District

Total Project Cost Summary

Project: **Central Everglades Planning Project - P2 # 370939** | Report Type: **LPP** | Authority: **CG**

Location: Central and Southern Florida | Contingency Development: Crystal Ball | TPCS Preparation Date: 25-Feb-14

District: SAJ -Jacksonville District | CWCCIS Issue: **9/1/2013** | Program Year: 2014

POC: Tracy Leeser

Scope Synopsis: The recommended plan will provide approximately 200,000 ac-ft per year of additional water flow to the Everglades by redirecting through the EAA water which is currently being discharged to tide via the St. Lucie and Caloosahatchee Estuaries and providing FEB storage to attenuate flow rates, prior to water quality treatment using available, off-peak capacity of the state-operated STA-2 and STA-3/4. Following water quality treatment, this additional flow quantity will be re-distributed as inflows to WCA 2A and WCA 3A, and the recommended plan features will modify the quantity, quality, timing, and spatial distribution of flows into and through WCA 3A, WCA 3B, and ENP to Florida Bay in order to meet the project objectives. This plan would be accomplished by a combination of modifications to the existing Central and South Florida project components, construction of additional components, and modifications to current approved water control manuals. Several proposed or existing levees, canals, and culverts, and pump stations would be constructed, modified, or removed to improve the flow of water through the system.

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*						TOTAL PROJECT COST (FULLY FUNDED)			
Civil Works		Risk Based				Program Price Level Date: 2014-1Q									
WBS	Feature Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	SPENT* ($K)	Total ($K)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
06	FISH & WILDLIFE FACILITIES	72,516	31,907	44%	104,423	1%	73,429	32,309	105,738		105,738	42%	104,076	45,793	149,869
09	CHANNELS & CANALS	252,726	111,199	44%	363,925	2%	257,235	113,183	370,418		370,418	40%	359,257	158,073	517,330
11	LEVEES & FLOODWALLS	273,504	120,342	44%	393,846	1%	277,277	122,002	399,279		399,279	55%	430,461	189,403	619,864
13	PUMPING PLANT	91,808	40,396	44%	132,204	1%	92,624	40,754	133,378		133,378	28%	118,678	52,218	170,896
14	RECREATION FACILITIES	4,440	1,954	44%	6,394	1%	4,479	1,971	6,450		6,450	37%	6,158	2,710	8,868
15	FLOODWAY CONTROL & DIVERSION STRUCTURE	234,173	103,036	44%	337,209	1%	237,122	104,334	341,455		341,455	29%	306,864	135,020	441,884
18	CULTURAL RESOURCE PRESERVATION	18,065	7,949	44%	26,014	1%	18,226	8,019	26,245		26,245	42%	25,832	11,366	37,198
	S/T	*947,232*	*416,782*	*44%*	*1,364,014*	*1%*	*960,392*	*422,572*	*1,382,965*		*1,382,965*	*41%*	*1,351,327*	*594,584*	*1,945,910*
01	LANDS AND DAMAGES	35,328	1,314	4%	36,642		35,328	1,314	36,642		36,642	4%	36,842	1,980	38,822
	S/T	*35,328*	*1,314*	*4%*	*36,642*		*35,328*	*1,314*	*36,642*		*36,642*	*4%*	*36,842*	*1,980*	*38,822*
30	PLANNING ENGINEERING AND DESIGN	235,579	103,655	44%	339,234	2%	239,706	105,471	345,177		345,177	113%	511,128	224,896	736,024
	S/T	*235,579*	*103,655*	*44%*	*339,234*	*2%*	*239,706*	*105,471*	*345,177*		*345,177*	*113%*	*511,128*	*224,896*	*736,024*
31	CONSTRUCTION MANAGEMENT	91,845	40,412	44%	132,257	2%	93,454	41,120	134,574		134,574	140%	224,324	98,703	323,027
	S/T	*91,845*	*40,412*	*44%*	*132,257*	*2%*	*93,454*	*41,120*	*134,574*		*134,574*	*140%*	*224,324*	*98,703*	*323,027*
32	HTRW	625	275	44%	900	1%	633	278	911		911	42%	897	395	1,292
	S/T	*625*	*275*	*44%*	*900*	*1%*	*633*	*278*	*911*		*911*	*42%*	*897*	*395*	*1,292*
	Totals	1,310,609	562,438	43%	1,873,047	1%	1,329,513	570,756	1,900,269		1,900,269	60%	2,124,517	920,558	3,045,075

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CHIEF, DPM

Estimated Federal Cost:	50%	1,522,537
Estimated Non-Federal Cost:	50%	1,522,537
Estimated Total Project Cost:		3,045,075

*Spent Cost as of:

	Cost ($k)	Contingency ($k)	Totals ($k)
Project First Cost for Report:	$1,329,513	$570,756	1,900,269
Total Project Cost used to provide Sponsor information:	$2,124,517	$920,558	3,045,075

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: S-623 Gated Spillway 3700 CFS in STA 3/4 Canal		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
15 FLOODWAY CONTROL & DIVERSION STRUC.		21,549	9,482	44.0%	31,031	1.3%	21,820	9,601	31,421		2036-3Q	54.7%	33,346	14,672	48,018
Construction Activities	*Total*	21,549	9,482		31,031		21,820	9,601	31,421				33,346	14,672	48,018
30 Planning Engineering and Design	*27.5%*	5,926	2,607	44.0%	8,533	1.8%	6,030	2,653	8,683		2034-1Q	152.1%	14,940	6,574	21,514
Planning Engineering and Design	*Total*	5,926	2,607		8,533		6,030	2,653	8,683				14,940	6,574	21,514
31 Construction Management (S&A)	*10.5%*	2,263	996	44.0%	3,258	1.8%	2,302	1,013	3,315		2036-3Q	188.2%	6,522	2,869	9,391
Construction Management	*Total*	2,263	996		3,258		2,302	1,013	3,315				6,522	2,869	9,391
S-623 Gated Spillway 3700 CFS in STA 3/4 Canal	*Total*	29,738	13,085		42,822		30,152	13,267	43,419				54,808	24,115	78,923

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: S-624 Gated Sag Culverts (FEB inflow structure) 1550 CFS on STA 3/4 Supply Canal		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
15 FLOODWAY CONTROL & DIVERSION STRUC.		23,774	10,461	44.0%	34,235	1.3%	24,073	10,592	34,666		2033-1Q	44.9%	34,440	15,153	49,593
Construction Activities	*Total*	23,774	10,461		34,235		24,073	10,592	34,666				34,440	15,153	49,593
30 Planning Engineering and Design	*27.5%*	6,538	2,877	44.0%	9,415	1.8%	6,652	2,927	9,579		2031-1Q	115.5%	14,087	6,198	20,285
Planning Engineering and Design	*Total*	6,538	2,877		9,415		6,652	2,927	9,579				14,087	6,198	20,285
31 Construction Management (S&A)	*10.5%*	2,496	1,098	44.0%	3,595	1.8%	2,540	1,118	3,658		2033-1Q	139.%%	5,967	2,625	8,592
Construction Management	*Total*	2,496	1,098		3,595		2,540	1,118	3,658				5,967	2,625	8,592
S-624 Gated Sag Culverts (FEB inflow structure) 1550 CFS on STA 3/4 Supply Canal	*Total*	32,808	14,436		47,244		33,266	14,637	47,903				54,493	23,977	78,470

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ-Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: S-625 Gated Culverts (FEB discharge structure) 1550 CFS Discharge structure in FEB Perimeter		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
15 FLOODWAY CONTROL & DIVERSION STRUC.		17,234	7,583	44.0%	24,817	1.3%	17,451	7,678	25,129		2033-4Q	46.9%	25,324	11,143	36,466
Construction Activities	*Total*	17,234	7,583		24,817		17,451	7,678	25,129				25,324	11,143	36,466
30 Planning Engineering and Design	27.5%	4,739	2,085	44.0%	6,825	1.8%	4,822	2,122	6,944		2032-1Q	126.8%	10,750	4,730	15,481
Planning Engineering and Design	*Total*	4,739	2,085		6,825		4,822	2,122	6,944				10,750	4,730	15,481
31 Construction Management (S&A)	10.5%	1,810	796	44.0%	2,606	1.8%	1,841	810	2,651		2033-4Q	148.8%	4,502	1,981	6,483
Construction Management	*Total*	1,810	796		2,606		1,841	810	2,651				4,502	1,981	6,483
S-625 Gated Culverts (FEB discharge structure) 1550 CFS Discharge structure in FEB Perimeter	*Total*	23,783	10,464		34,247		24,115	10,610	34,725				40,576	17,854	58,430

***Contract Footnote:** All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.*

Location: Central and Southern Fl District: SAJ-Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: S-626 Seepage Pump Station 700 CFS West Side of Seepage Canal C-626		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
13 PUMPING PLANT		26,391	11,612	44.0%	38,003	.9%	26,626	11,715	38,341		2034-4Q	49.2%	39,372	17,324	56,695
Construction Activities	*Total*	26,391	11,612		38,003		26,626	11,715	38,341				39,372	17,324	56,695
30 Planning Engineering and Design	*27.5%*	7,258	3,193	44.0%	10,451	1.8%	7,385	3,249	10,634		2033-1Q	139.9%	17,347	7,633	24,980
Planning Engineering and Design	*Total*	7,258	3,193		10,451		7,385	3,249	10,634				17,347	7,633	24,980
31 Construction Management (S&A)	*10.5%*	2,771	1,219	44.0%	3,990	1.8%	2,820	1,241	4,060		2034-4Q	162.5%	7,273	3,200	10,473
Construction Management	*Total*	2,771	1,219		3,990		2,820	1,241	4,060				7,273	3,200	10,473
S-626 Seepage Pump Station 700 CFS West Side of Seepage Canal C-626	*Total*	36,420	16,025		52,444		36,830	16,205	53,035				63,992	28,157	92,149

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: S-627 Emergency Overflow Weir 445 CFS Between A-2 and A-1 FEB just North of S-628		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
15 FLOODWAY CONTROL & DIVERSION STRUC.		290	128	44.0%	418	1.3%	294	129	423		2045-1Q	81.6%	527	232	758
Construction Activities	*Total*	290	128		418		294	129	423				527	232	758
30 Planning Engineering and Design	*27.5%*	80	35	44.0%	115	1.8%	81	36	117		2044-1Q	330.6%	343	151	495
Planning Engineering and Design	*Total*	80	35		115		81	36	117				343	151	495
31 Construction Management (S&A)	*10.5%*	30	13	44.0%	44	1.8%	31	14	45		2045-1Q	354.3%	138	61	199
Construction Management	*Total*	30	13		44		31	14	45				138	61	199
S-627 Emergency Overflow Weir 445 CFS Between A-2 and A-1 FEB just North of S-628	*Total*	400	176		576		406	179	584				1,008	444	1,452

***Contract Footnote:** All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.*

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: S-628 Gated Culvert FEB Intake / Discharge Structure 930 CFS Between A-2 and A-1 FEB		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
15 **FLOODWAY CONTROL & DIVERSION STRUC.**		24,745	10,888	44.0%	35,633	1.3%	25,057	11,025	36,081		2035-4Q	52.6%	37,756	16,612	54,368
Construction Activities	*Total*	24,745	10,888		35,633		25,057	11,025	36,081				37,756	16,612	54,368
30 **Planning Engineering and Design**	*27.5%*	6,805	2,994	44.0%	9,799	1.8%	6,924	3,047	9,971		2034-1Q	152.1%	17,156	7,549	24,705
Planning Engineering and Design	*Total*	6,805	2,994		9,799		6,924	3,047	9,971				17,156	7,549	24,705
31 **Construction Management (S&A)**	*10.5%*	2,598	1,143	44.0%	3,741	1.8%	2,644	1,163	3,807		2035-4Q	176.9%	7,195	3,166	10,360
Construction Management	*Total*	2,598	1,143		3,741		2,644	1,163	3,807				7,195	3,166	10,360
S-628 Gated Culvert FEB Intake / Discharge Structure 930 CFS Between A-2 and A-1 FEB	*Total*	34,148	15,025		49,173		34,624	15,235	49,859				62,106	27,327	89,433

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: L-624 Levee FEB Perimeter Levee		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
11 LEVEES & FLOODWALLS		111,131	48,898	44.0%	160,029	1.4%	112,664	49,572	162,236		2043-2Q	75.9%	195,490	86,016	281,505
14 RECREATION FACILITIES		1,012	445	44.0%	1,457	.9%	1,021	449	1,470		2043-2Q	75.1%	1,772	779	2,551
Construction Activities	*Total*	112,143	49,343		161,486		113,685	50,021	163,707				197,261	86,795	284,057
30 Planning Engineering and Design	*27.5%*	30,839	13,569	44.0%	44,409	1.8%	31,380	13,807	45,187		2039-4Q	243.%	105,790	46,548	152,338
Planning Engineering and Design	*Total*	30,839	13,569		44,409		31,380	13,807	45,187				105,790	46,548	152,338
31 Construction Management (S&A)	*10.5%*	11,775	5,181	44.0%	16,956	1.8%	11,981	5,272	17,253		2043-2Q	313.6%	48,700	21,428	70,128
Construction Management	*Total*	11,775	5,181		16,956		11,981	5,272	17,253				48,700	21,428	70,128
L-624 Levee FEB Perimeter Levee	*Total*	154,757	68,093		222,851		157,046	69,100	226,146				351,752	154,771	506,523

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: L-625 Levee FEB Interior Inflow Canal Levee		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
11 LEVEES & FLOODWALLS		22,624	9,955	44.0%	32,579	1.4%	22,936	10,092	33,028		2045-4Q	84.4%	41,718	18,356	60,074
Construction Activities	*Total*	22,624	9,955		32,579		22,936	10,092	33,028				41,718	18,356	60,074
30 Planning Engineering and Design	*27.5%*	6,222	2,738	44.0%	8,959	1.8%	6,331	2,785	9,116		2044-1Q	330.6%	26,793	11,789	38,582
Planning Engineering and Design	*Total*	6,222	2,738		8,959		6,331	2,785	9,116				26,793	11,789	38,582
31 Construction Management (S&A)	*10.5%*	2,376	1,045	44.0%	3,421	1.8%	2,417	1,064	3,481		2045-4Q	373.9%	11,236	4,944	16,180
Construction Management	*Total*	2,376	1,045		3,421		2,417	1,064	3,481				11,236	4,944	16,180
L-625 Levee FEB Interior Inflow Canal Levee	*Total*	31,221	13,737		44,958		31,684	13,941	45,625				79,748	35,089	114,836

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ-Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: C-624 Inflow Canal 1550 CFS West Side of FEB		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
09 CHANNELS & CANALS		8,676	3,817	44.0%	12,493	1.8%	8,831	3,886	12,716		2045-3Q	84.3%	15,986	7,034	23,020
Construction Activities	*Total*	8,676	3,817		12,493		8,831	3,886	12,716				15,986	7,034	23,020
30 Planning Engineering and Design	*27.5%*	2,386	1,050	44.0%	3,436	1.8%	2,428	1,068	3,496		2044-1Q	330.6%	10,275	4,521	14,796
Planning Engineering and Design	*Total*	2,386	1,050		3,436		2,428	1,068	3,496				10,275	4,521	14,796
31 Construction Management (S&A)	*10.5%*	911	401	44.0%	1,312	1.8%	927	408	1,335		2045-3Q	366.7%	4,251	1,871	6,122
Construction Management	*Total*	911	401		1,312		927	408	1,335				4,251	1,871	6,122
C-624 Inflow Canal 1550 CFS West Side of FEB	*Total*	11,973	5,268		17,241		12,185	5,362	17,547				30,512	13,425	43,938

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: C-624E Spreader Canal Northern Boundary of FEB		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
09 CHANNELS & CANALS		76,900	33,836	44.0%	110,736	1.8%	78,272	34,440	112,712		2039-3Q	64.6%	126,564	55,688	182,252
Construction Activities	*Total*	76,900	33,836		110,736		78,272	34,440	112,712				126,564	55,688	182,252
30 Planning Engineering and Design	27.5%	21,148	9,305	44.0%	30,452	1.8%	21,518	9,468	30,986		2036-3Q	188.2%	60,953	26,819	87,772
Planning Engineering and Design	*Total*	21,148	9,305		30,452		21,518	9,468	30,986				60,953	26,819	87,772
31 Construction Management (S&A)	10.5%	8,075	3,553	44.0%	11,627	1.8%	8,216	3,615	11,831		2039-3Q	238.4%	27,328	12,024	39,352
Construction Management	*Total*	8,075	3,553		11,627		8,216	3,615	11,831				27,328	12,024	39,352
C-624E Spreader Canal Northern Boundary of FEB	*Total*	106,122	46,694		152,816		108,006	47,523	155,529				214,844	94,532	309,376

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ-Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: C-625E Collection Canal 400 CFS FEB Interior Collection Canal Along Southern Perimeter		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
09 CHANNELS & CANALS		6,299	2,772	44.0%	9,071	1.8%	6,411	2,821	9,232		2037-2Q	57.8%	9,937	4,372	14,309
Construction Activities	*Total*	6,299	2,772		9,071		6,411	2,821	9,232				9,937	4,372	14,309
30 Planning Engineering and Design	*27.5%*	1,732	762	44.0%	2,494	1.8%	1,763	776	2,538		2036-1Q	180.6%	4,861	2,139	7,000
Planning Engineering and Design	*Total*	1,732	762		2,494		1,763	776	2,538				4,861	2,139	7,000
31 Construction Management (S&A)	*10.5%*	661	291	44.0%	952	1.8%	673	296	969		2037-2Q	200.9%	1,984	873	2,857
Construction Management	*Total*	661	291		952		673	296	969				1,984	873	2,857
C-625E Collection Canal 400 CFS FEB Interior Collection Canal Along Southern Perimeter	*Total*	8,693	3,825		12,517		8,847	3,893	12,740				16,781	7,384	24,165

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: C-625W Outflow Canal FEB exterior Outflow Canal between S-625 and G-372 HW		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
09 CHANNELS & CANALS		7,258	3,194	44.0%	10,452	1.8%	7,387	3,250	10,638		2037-3Q	58.5%	11,504	5,062	16,566
Construction Activities	*Total*	7,258	3,194		10,452		7,387	3,250	10,638				11,504	5,062	16,566
30 Planning Engineering and Design	*27.5%*	1,996	878	44.0%	2,874	1.8%	2,031	894	2,925		2036-1Q	180.6%	5,601	2,464	8,065
Planning Engineering and Design	*Total*	1,996	878		2,874		2,031	894	2,925				5,601	2,464	8,065
31 Construction Management (S&A)	*10.5%*	762	335	44.0%	1,097	1.8%	775	341	1,117		2037-3Q	204.1%	2,317	1,020	3,337
Construction Management	*Total*	762	335		1,097		775	341	1,117				2,317	1,020	3,337
C-625W Outflow Canal FEB exterior Outflow Canal between S-625 and G-372 HW	*Total*	10,016	4,407		14,423		10,194	4,485	14,679				19,422	8,546	27,968

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: C-626 Seepage Canal 400 CFS West and Northern Exterior Perimeter of FEB		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
09 CHANNELS & CANALS		26,747	11,769	44.0%	38,516	1.8%	27,224	11,979	39,203		2034-2Q	49.1%	39,877	17,546	57,423
Construction Activities	*Total*	26,747	11,769		38,516		27,224	11,979	39,203				39,877	17,546	57,423
30 Planning Engineering and Design	*27.5%*	7,355	3,236	44.0%	10,592	1.8%	7,484	3,293	10,777		2032-1Q	126.8%	16,684	7,341	24,026
Planning Engineering and Design	*Total*	7,355	3,236		10,592		7,484	3,293	10,777				16,684	7,341	24,026
31 Construction Management (S&A)	*10.5%*	2,808	1,236	44.0%	4,044	1.8%	2,858	1,257	4,115		2034-2Q	155.4%	7,174	3,157	10,331
Construction Management	*Total*	2,808	1,236		4,044		2,858	1,257	4,115				7,174	3,157	10,331
C-626 Seepage Canal 400 CFS West and Northern Exterior Perimeter of FEB	*Total*	36,911	16,241		53,152		37,566	16,529	54,095				63,736	28,044	91,779

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ-Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: S-620 Gated Culvert 500 CFS in L-6 Canal		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
15 FLOODWAY CONTROL & DIVERSION STRUC.		10,041	4,418	44.0%	14,459	1.3%	10,167	4,474	14,641		2019-2Q	11.8%	11,230	4,941	16,171
Construction Activities	*Total*	10,041	4,418		14,459		10,167	4,474	14,641				11,230	4,941	16,171
30 Planning Engineering and Design	*27.5%*	2,761	1,215	44.0%	3,976	1.8%	2,810	1,236	4,046		2018-1Q	19.5%	3,301	1,452	4,753
Planning Engineering and Design	*Total*	2,761	1,215		3,976		2,810	1,236	4,046				3,301	1,452	4,753
31 Construction Management (S&A)	*10.5%*	1,054	464	44.0%	1,518	1.8%	1,073	472	1,545		2019-2Q	26.%	1,328	584	1,912
Construction Management	*Total*	1,054	464		1,518		1,073	472	1,545				1,328	584	1,912
S-620 Gated Culvert 500 CFS in L-6 Canal	*Total*	13,857	6,097		19,953		14,050	6,182	20,232				15,858	6,978	22,836

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: 5-621 Gated Spillway 2500 CFS On STA 3/4 Outflow Canal		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
15 FLOODWAY CONTROL & DIVERSION STRUC.		22,205	9,770	44.0%	31,975	1.3%	22,485	9,893	32,378		2022-2Q	18.3%	26,276	11,562	37,838
Construction Activities	*Total*	22,205	9,770		31,975		22,485	9,893	32,378				26,276	11,562	37,838
30 Planning Engineering and Design	*27.5%*	6,106	2,687	44.0%	8,793	1.8%	6,213	2,734	8,947		2020-3Q	32.8%	8,100	3,568	11,677
Planning Engineering and Design	*Total*	6,106	2,687		8,793		6,213	2,734	8,947				8,109	3,568	11,677
31 Construction Management (S&A)	*10.5%*	2,332	1,026	44.0%	3,357	1.8%	2,372	1,044	3,416		2022-2Q	43.1%	3,336	1,468	4,803
Construction Management	*Total*	2,332	1,026		3,357		2,372	1,044	3,416				3,336	1,468	4,803
5-621 Gated Spillway 2500 CFS On STA 3/4 Outflow Canal	*Total*	30,643	13,483		44,126		31,070	13,671	44,741				37,721	16,597	54,318

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: S-622 Gated Spillway 500 CFS in L-5 Canal		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
15 **FLOODWAY CONTROL & DIVERSION STRUC.**		13,764	6,056	44.0%	19,820	1.3%	13,937	6,132	20,070		2021-1Q	15.6%	15,908	6,999	22,907
Construction Activities	*Total*	13,764	6,056		19,820		13,937	6,132	20,070				15,908	6,999	22,907
30 **Planning Engineering and Design**	*27.5%*	3,785	1,665	44.0%	5,451	1.8%	3,851	1,695	5,546		2019-3Q	27.3%	4,819	2,121	6,940
Planning Engineering and Design	*Total*	3,785	1,665		5,451		3,851	1,695	5,546				4,819	2,121	6,940
31 **Construction Management (S&A)**	*10.5%*	1,445	636	44.0%	2,081	1.8%	1,471	647	2,118		2021-1Q	35.6%	1,960	862	2,822
Construction Management	*Total*	1,445	636		2,081		1,471	647	2,118				1,960	862	2,822
S-622 Gated Spillway 500 CFS in L-5 Canal	*Total*	18,994	8,358		27,352		19,259	8,474	27,733				22,687	9,982	32,670

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: New S-8A Gated Culverts w. Canal 3080 and 1020 CFS in Miami and L-4 Canal		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
15 **FLOODWAY CONTROL & DIVERSION STRUC. 1020 CFS Structure and 3080 CFS Structure.. Short canal to connect**		49,033	21,575	44.0%	70,608	1.3%	49,650	21,846	71,497		2020-1Q	13.4%	55,613	24,470	80,083
Construction Activities	*Total*	49,033	21,575		70,608		49,650	21,846	71,497				55,613	24,470	80,083
30 **Planning Engineering and Design**	*27.5%*	13,484	5,933	44.0%	19,417	1.8%	13,720	6,037	19,757		2018-1Q	19.5%	16,118	7,092	23,209
Planning Engineering and Design	*Total*	13,484	5,933		19,417		13,720	6,037	19,757				16,118	7,092	23,209
31 **Construction Management (S&A)**	*10.5%*	5,148	2,265	44.0%	7,414	1.8%	5,239	2,305	7,544		2020-1Q	30.%	6,695	2,946	9,640
Construction Management	*Total*	5,148	2,265		7,414		5,239	2,305	7,544				6,695	2,946	9,640
New S-8A Gated Culverts w. Canal 3080 and 1020 CFS in Miami and L-4 Canal	*Total*	67,666	29,773		97,438		68,609	30,188	98,797				78,425	34,507	112,933

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ - Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: S-630 Pump Station 360 CFS in L-4 Canal		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
13 PUMPING PLANT		30,424	13,387	44.0%	43,811	.9%	30,694	13,506	44,200		2021-1Q	15.2%	35,034	15,415	50,449
Construction Activities	*Total*	30,424	13,387		43,811		30,694	13,506	44,200				35,034	15,415	50,449
30 Planning Engineering and Design	27.5%	8,367	3,681	44.0%	12,048	1.8%	8,513	3,746	12,259		2019-3Q	27.3%	10,653	4,687	15,340
Planning Engineering and Design	*Total*	8,367	3,681		12,048		8,513	3,746	12,259				10,653	4,687	15,340
31 Construction Management (S&A)	10.5%	3,195	1,406	44.0%	4,600	1.8%	3,250	1,430	4,681		2021-1Q	35.6%	4,333	1,906	6,239
Construction Management	*Total*	3,195	1,406		4,600		3,250	1,430	4,681				4,333	1,906	6,239
S-630 Pump Station 360 CFS in L-4 Canal	*Total*	41,985	18,473		60,459		42,458	18,682	61,140				50,019	22,009	72,028

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ-Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: L-4 Levee Removal L-4 Interior Levee		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
11 LEVEES & FLOODWALLS		2,410	1,060	44.0%	3,470	1.4%	2,443	1,075	3,518		2020-4Q	15.2%	2,776	1,221	3,997
Construction Activities	*Total*	2,410	1,060		3,470		2,443	1,075	3,518				2,776	1,221	3,997
30 Planning Engineering and Design	*27.5%*	663	292	44.0%	954	1.8%	674	297	971		2019-3Q	27.3%	844	371	1,215
Planning Engineering and Design	*Total*	663	292		954		674	297	971				844	371	1,215
31 Construction Management (S&A)	*10.5%*	253	111	44.0%	364	1.8%	257	113	371		2020-4Q	34.2%	340	149	489
Construction Management	*Total*	253	111		364		257	113	371				340	149	489
L-4 Levee Removal L-4 Interior Levee	*Total*	3,326	1,463		4,789		3,375	1,485	4,860				3,959	1,742	5,702

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: Miami Canal Backfill		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
09 CHANNELS & CANALS		94,138	41,421	44.0%	135,559	1.8%	95,818	42,160	137,977		2024-1Q	22.9%	115,717	50,916	166,633
14 RECREATION FACILITIES		577	254	44.0%	831	.9%	582	256	838		2024-1Q	21.8%	703	309	1,012
Construction Activities	*Total*	94,715	41,675		136,390		96,400	42,416	138,816				116,421	51,225	167,646
30 Planning Engineering and Design	27.5%	26,047	11,461	44.0%	37,507	1.8%	26,503	11,661	38,164		2021-4Q	40.1%	36,478	16,050	52,529
Planning Engineering and Design	*Total*	26,047	11,461		37,507		26,503	11,661	38,164				36,478	16,050	52,529
31 Construction Management (S&A)	10.5%	9,945	4,376	44.0%	14,321	1.8%	10,119	4,452	14,572		2024-1Q	54.5%	15,370	6,763	22,133
Construction Management	*Total*	9,945	4,376		14,321		10,119	4,452	14,572				15,370	6,763	22,133
Miami Canal Backfill	*Total*	130,707	57,511		188,218		133,022	58,530	191,552				168,269	74,038	242,307

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ-Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: Tree Islands Mounds Miami Canal		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		Risk Based													
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
09 CHANNELS & CANALS		6,993	3,077	44.0%	10,070	1.8%	7,118	3,132	10,250		2025-3Q	26.5%	8,843	3,891	12,734
Construction Activities	*Total*	6,993	3,077		10,070		7,118	3,132	10,250				8,843	3,891	12,734
30 Planning Engineering and Design	*27.5%*	1,923	846	44.0%	2,769	1.8%	1,957	861	2,818		2024-1Q	54.5%	2,972	1,308	4,280
Planning Engineering and Design	*Total*	1,923	846		2,769		1,957	861	2,818				2,972	1,308	4,280
31 Construction Management (S&A)	*10.5%*	734	323	44.0%	1,057	1.8%	747	329	1,076		2025-3Q	65.3%	1,214	534	1,748
Construction Management	*Total*	734	323		1,057		747	329	1,076				1,214	534	1,748
Tree Islands Mounds Miami Canal	*Total*	9,650	4,246		13,896		9,822	4,322	14,143				13,029	5,733	18,762

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: L-5 East Canal 500 CFS Remnant L-5 Canal East		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
09 CHANNELS & CANALS		11,437	5,032	44.0%	16,469	1.8%	11,641	5,122	16,763		2022-2Q	18.9%	13,604	5,986	19,590
Construction Activities	*Total*	11,437	5,032		16,469		11,641	5,122	16,763				13,604	5,986	19,590
30 Planning Engineering and Design	*27.5%*	3,145	1,384	44.0%	4,529	1.8%	3,200	1,408	4,608		2020-3Q	32.8%	4,177	1,838	6,015
Planning Engineering and Design	*Total*	3,145	1,384		4,529		3,200	1,408	4,608				4,177	1,838	6,015
31 Construction Management (S&A)	*10.5%*	1,201	528	44.0%	1,729	1.8%	1,222	538	1,760		2022-2Q	43.1%	1,718	756	2,474
Construction Management	*Total*	1,201	528		1,729		1,222	538	1,760				1,718	756	2,474
L-5 East Canal 500 CFS Remnant L-5 Canal East	*Total*	15,783	6,945		22,728		16,063	7,068	23,131				19,499	8,580	28,078

***Contract Footnote:** All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.*

Location: Central and Southern Fl District: SAJ Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: L-5 West Canal 3000 CFS L-5 Canal West		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
09 CHANNELS & CANALS		14,278	6,282	44.0%	20,560	1.8%	14,533	6,394	20,927		2023-1Q	20.6%	17,224	7,578	24,802
Construction Activities	*Total*	14,278	6,282		20,560		14,533	6,394	20,927				17,224	7,578	24,802
30 Planning Engineering and Design	*27.5%*	3,926	1,728	44.0%	5,654	1.8%	3,995	1,758	5,753		2021-2Q	37.%	5,381	2,367	7,748
Planning Engineering and Design	*Total*	3,926	1,728		5,654		3,995	1,758	5,753				5,381	2,367	7,748
31 Construction Management (S&A)	*10.5%*	1,499	660	44.0%	2,159	1.8%	1,525	671	2,197		2023-1Q	47.9%	2,217	976	3,193
Construction Management	*Total*	1,499	660		2,159		1,525	671	2,197				2,217	976	3,193
L-5 West Canal 3000 CFS L-5 Canal West	*Total*	19,704	8,670		28,373		20,053	8,824	28,877				24,822	10,922	35,743

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ-Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: S-333N Gated Spillway w/ New Canal 1150 CFS Just North of Existing S-333		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
14 RECREATION FACILITIES		951	418	44.0%	1,369	.9%	959	422	1,382		2025-3Q	25.3%	1,192	524	1,717
15 FLOODWAY CONTROL & DIVERSION STRUC. Include connection canal		11,494	5,057	44.0%	16,551	1.3%	11,639	5,121	16,760		2025-3Q	25.8%	14,460	6,362	20,822
Construction Activities	*Total*	12,445	5,476		17,921		12,598	5,543	18,141				15,652	6,887	22,539
30 Planning Engineering and Design	*27.5%*	3,422	1,506	44.0%	4,928	1.8%	3,482	1,532	5,015		2024-1Q	54.5%	5,289	2,327	7,617
Planning Engineering and Design	*Total*	3,422	1,506		4,928		3,482	1,532	5,015				5,289	2,327	7,617
31 Construction Management (S&A)	*10.5%*	1,307	575	44.0%	1,882	1.8%	1,330	585	1,915		2025-3Q	65.3%	2,161	951	3,111
Construction Management	*Total*	1,307	575		1,882		1,330	585	1,915				2,161	951	3,111
S-333N Gated Spillway w/ New Canal 1150 CFS Just North of Existing S-333	*Total*	17,174	7,557		24,731		17,410	7,660	25,071				23,102	10,165	33,267

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: New S-356 Pump Station 1000 CFS In Vicinity of Existing S-356		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
13 PUMPING PLANT		34,993	15,397	44.0%	50,390	.9%	35,304	15,534	50,838		2026-1Q	26.5%	44,272	19,480	63,751
Construction Activities	*Total*	34,993	15,397		50,390		35,304	15,534	50,838				44,272	19,480	63,751
30 Planning Engineering and Design	*27.5%*	9,623	4,234	44.0%	13,857	1.8%	9,792	4,308	14,100		2024-1Q	54.5%	14,872	6,544	21,416
Planning Engineering and Design	*Total*	9,623	4,234		13,857		9,792	4,308	14,100				14,872	6,544	21,416
31 Construction Management (S&A)	*10.5%*	3,674	1,617	44.0%	5,291	1.8%	3,739	1,645	5,384		2026-1Q	69.2%	6,216	2,735	8,951
Construction Management	*Total*	3,674	1,617		5,291		3,739	1,645	5,384				6,216	2,735	8,951
New S-356 Pump Station 1000 CFS In Vicinity of Existing S-356	*Total*	48,290	21,248		69,538		48,834	21,487	70,321				65,360	28,758	94,118

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: S-631 Gated Culvert 500 CFS in L-67A		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
15 FLOODWAY CONTROL & DIVERSION STRUC.		6,910	3,040	44.0%	9,950	1.3%	6,997	3,079	10,076		2025-3Q	25.8%	8,693	3,825	12,518
Construction Activities	*Total*	6,910	3,040		9,950		6,997	3,079	10,076				8,693	3,825	12,518
30 Planning Engineering and Design	*27.5%*	1,900	836	44.0%	2,736	1.8%	1,934	851	2,784		2024-1Q	54.5%	2,937	1,292	4,229
Planning Engineering and Design	*Total*	1,900	836		2,736		1,934	851	2,784				2,937	1,292	4,229
31 Construction Management (S&A)	*10.5%*	726	319	44.0%	1,045	1.8%	738	325	1,063		2025-3Q	65.3%	1,200	528	1,727
Construction Management	*Total*	726	319		1,045		738	325	1,063				1,200	528	1,727
S-631 Gated Culvert 500 CFS in L-67A	*Total*	9,536	4,196		13,732		9,669	4,254	13,923				12,830	5,645	18,475

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ-Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: S-632 Gated Culvert 500 CFS in L-67A		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
15 **FLOODWAY CONTROL & DIVERSION STRUC.**		6,953	3,059	44.0%	10,012	1.3%	7,041	3,098	10,138		2027-3Q	30.6%	9,083	3,996	13,079
Construction Activities	*Total*	6,953	3,059		10,012		7,041	3,098	10,138				9,083	3,996	13,079
30 **Planning Engineering and Design**	*27.5%*	1,912	841	44.0%	2,753	1.8%	1,946	856	2,802		2026-1Q	69.2%	3,235	1,423	4,658
Planning Engineering and Design	*Total*	1,912	841		2,753		1,946	856	2,802				3,235	1,423	4,658
31 **Construction Management (S&A)**	*10.5%*	730	321	44.0%	1,051	1.8%	743	327	1,070		2027-3Q	81.5%	1,325	583	1,908
Construction Management	*Total*	730	321		1,051		743	327	1,070				1,325	583	1,908
S-632 Gated Culvert 500 CFS in L-67A	*Total*	9,595	4,222		13,817		9,729	4,281	14,010				13,643	6,003	19,645

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ-Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: S-633 Gated Culvert 500 CFS in L-67A		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
14 RECREATION FACILITIES		1,660	730	44.0%	2,390	.9%	1,675	737	2,412		2027-3Q	30.2%	2,161	951	3,111
15 FLOODWAY CONTROL & DIVERSION STRUC.		6,992	3,076	44.0%	10,068	1.3%	7,080	3,115	10,195		2027-3Q	30.6%	9,134	4,019	13,152
Construction Activities	*Total*	8,652	3,807		12,459		8,755	3,852	12,607				11,294	4,969	16,264
30 Planning Engineering and Design	27.5%	2,379	1,047	44.0%	3,426	1.8%	2,421	1,065	3,486		2026-1Q	69.2%	4,025	1,771	5,796
Planning Engineering and Design	*Total*	2,379	1,047		3,426		2,421	1,065	3,486				4,025	1,771	5,796
31 Construction Management (S&A)	10.5%	908	400	44.0%	1,308	1.8%	924	407	1,331		2027-3Q	81.5%	1,649	726	2,374
Construction Management	*Total*	908	400		1,308		924	407	1,331				1,649	726	2,374
S-633 Gated Culvert 500 CFS in L-67A	*Total*	11,940	5,253		17,193		12,100	5,324	17,424				16,968	7,466	24,434

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ-Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: L-67C Gap Levee Removal Gap In L-67C		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	SPENT ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
11 LEVEES & FLOODWALLS		800	352	44.0%	1,152	1.4%	811	357	1,168		2027-1Q	29.5%	1,036	456	1,492
Construction Activities	*Total*	800	352		1,152		811	357	1,168				1,036	456	1,492
30 Planning Engineering and Design	27.5%	220	97	44.0%	317	1.8%	224	98	322		2026-1Q	69.2%	372	164	536
Planning Engineering and Design	*Total*	220	97		317		224	98	322				372	164	536
31 Construction Management (S&A)	10.5%	84	37	44.0%	121	1.8%	85	38	123		2027-1Q	77.3%	149	66	214
Construction Management	*Total*	84	37		121		85	38	123				149	66	214
L-67C Gap Levee Removal Gap In L-67C	*Total*	1,104	486		1,590		1,120	493	1,613				1,557	685	2,243

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ-Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: L-67D New Levee In WCA 3B		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
11 LEVEES & FLOODWALLS		82,090	36,120	44.0%	118,210	1.4%	83,223	36,618	119,840		2030-2Q	37.7%	113,062	49,747	162,809
14 RECREATION FACILITIES		163	72	44.0%	235	.9%	164	72	237		2030-2Q	37.1%	223	98	322
Construction Activities	*Total*	82,253	36,191		118,444		83,387	36,690	120,077				113,285	49,846	163,131
30 Planning Engineering and Design	27.5%	22,620	9,953	44.0%	32,572	1.8%	23,016	10,127	33,143		2028-2Q	88.1%	42,547	18,721	61,267
Planning Engineering and Design	*Total*	22,620	9,953		32,572		23,016	10,127	33,143				42,547	18,721	61,267
31 Construction Management (S&A)	10.5%	8,637	3,800	44.0%	12,437	1.8%	8,788	3,867	12,655		2030-2Q	107.4%	17,910	7,880	25,791
Construction Management	*Total*	8,637	3,800		12,437		8,788	3,867	12,655				17,910	7,880	25,791
L-67D New Levee In WCA 3B	*Total*	113,509	49,944		163,453		115,191	50,684	165,875				173,742	76,447	250,189

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ-Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: L-67C Levee Removal L-67C Levee		Est Preparation Date: 03-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
11 LEVEES & FLOODWALLS		4,489	1,975	44.0%	6,464	1.4%	4,551	2,002	6,553		2027-1Q	29.5%	5,815	2,559	8,374
Construction Activities	Total	4,489	1,975		6,464		4,551	2,002	6,553				5,815	2,559	8,374
30 Planning Engineering and Design	27.5%	1,234	543	44.0%	1,778	1.8%	1,256	553	1,809		2026-1Q	69.2%	2,088	919	3,007
Planning Engineering and Design	Total	1,234	543		1,778		1,256	553	1,809				2,088	919	3,007
31 Construction Management (S&A)	10.5%	471	207	44.0%	679	1.8%	480	211	691		2027-1Q	77.3%	835	368	1,203
Construction Management	Total	471	207		679		480	211	691				835	368	1,203
L-67C Levee Removal L-67C Levee	Total	6,195	2,726		8,921		6,287	2,766	9,053				8,739	3,845	12,585

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: S-355W Gated Spillway 1230 CFS in L29 Canal, East of L-67D Levee Terminus and 2.6 mile Bridge		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
15 FLOODWAY CONTROL & DIVERSION STRUC.		19,081	8,396	44.0%	27,477	1.3%	19,321	8,501	27,823		2027-3Q	30.6%	24,926	10,967	35,893
Construction Activities	*Total*	19,081	8,396		27,477		19,321	8,501	27,823				24,926	10,967	35,893
30 Planning Engineering and Design	*27.5%*	5,247	2,309	44.0%	7,556	1.8%	5,339	2,349	7,688		2026-1Q	69.2%	8,877	3,906	12,783
Planning Engineering and Design	*Total*	5,247	2,309		7,556		5,339	2,349	7,688				8,877	3,906	12,783
31 Construction Management (S&A)	*10.5%*	2,004	882	44.0%	2,885	1.8%	2,039	897	2,936		2027-3Q	81.5%	3,637	1,600	5,237
Construction Management	*Total*	2,004	882		2,885		2,039	897	2,936				3,637	1,600	5,237
S-355W Gated Spillway 1230 CFS in L29 Canal, East of L-67D Levee Terminus and 2.6 mile Bridge	*Total*	26,332	11,586		37,918		26,699	11,748	38,447				37,439	16,473	53,913

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: L-29 Levee Removal in L-29 Levee		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based					Program Yr: 2014 Prog Level Date: 2014-1Q			as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
11 LEVEES & FLOODWALLS		10,036	4,416	44.0%	14,452	1.4%	10,174	4,477	14,651		2031-2Q	40.3%	14,085	6,197	20,283
14 RECREATION FACILITIES		77	34	44.0%	111	.9%	78	34	112		2031-2Q	39.7%	108	47	155
Construction Activities	*Total*	10,113	4,450		14,563		10,252	4,511	14,763				14,193	6,245	20,437
30 Planning Engineering and Design	27.5%	2,781	1,224	44.0%	4,005	1.8%	2,830	1,245	4,075		2030-1Q	104.9%	5,697	2,507	8,204
Planning Engineering and Design	*Total*	2,781	1,224		4,005		2,830	1,245	4,075				5,697	2,507	8,204
31 Construction Management (S&A)	20.5%	1,062	467	44.0%	1,529	1.8%	1,080	475	1,556		2031-2Q	118.2%	2,317	1,019	3,336
Construction Management	*Total*	1,062	467		1,529		1,080	475	1,556				2,317	1,019	3,336
L-29 Levee Removal in L-29 Levee	*Total*	13,956	6,141		20,097		14,162	6,231	20,394				22,207	9,771	31,977

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: Remove TT Road Removal Old Tamiami Trail (From L-67 Ext West to ENP Tram Rd)		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
11 LEVEES & FLOODWALLS		5,918	2,604	44.0%	8,522	1.4%	6,000	2,640	8,639		2031-3Q	41.%%	8,345	3,672	12,017
Construction Activities	*Total*	5,918	2,604		8,522		6,000	2,640	8,639				8,345	3,672	12,017
30 Planning Engineering and Design	*27.5%*	1,627	716	44.0%	2,344	1.8%	1,656	729	2,385		2030-1Q	104.9%	3,334	1,467	4,801
Planning Engineering and Design	*Total*	1,627	716		2,344		1,656	729	2,385				3,334	1,467	4,801
31 Construction Management (S&A)	*10.5%*	621	273	44.0%	895	1.8%	632	278	910		2031-3Q	121.1%	1,374	604	1,978
Construction Management	*Total*	621	273		895		632	278	910				1,374	604	1,978
Remove TT Road Removal Old Tamiami Trail (From L-67 Ext West to ENP Tram Rd)	*Total*	8,167	3,593		11,760		8,288	3,647	11,935				13,053	5,743	18,796

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ -Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: L-67 EXT Levee Removal and Canal Backfill in L-67 Ext Levee		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
11 LEVEES & FLOODWALLS		9,239	4,065	44.0%	13,304	1.4%	9,366	4,121	13,488		2031-2Q	40.3%	12,967	5,705	18,672
Construction Activities	*Total*	9,239	4,065		13,304		9,366	4,121	13,488				12,967	5,705	18,672
30 Planning Engineering and Design	*27.5%*	2,541	1,118	44.0%	3,659	1.8%	2,585	1,138	3,723		2030-1Q	104.9%	5,205	2,290	7,495
Planning Engineering and Design	*Total*	2,541	1,118		3,659		2,585	1,138	3,723				5,205	2,290	7,495
31 Construction Management (S&A)	*10.5%*	970	427	44.0%	1,397	1.8%	987	434	1,421		2031-2Q	118.2%	2,116	931	3,048
Construction Management	*Total*	970	427		1,397		987	434	1,421				2,116	931	3,048
L-67 EXT Levee Removal and Canal Backfill in L-67 Ext Levee	*Total*	12,750	5,610		18,360		12,939	5,693	18,632				20,288	8,927	29,214

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ-Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: L-31N Seepage Barrier Cutoff Wall In L-31N Levee just South of Tamiami Trail		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
11 LEVEES & FLOODWALLS		21,661	9,531	44.0%	31,192	1.4%	21,960	9,662	31,622		2032-4Q	44.4%	31,273	13,760	45,033
Construction Activities	*Total*	21,661	9,531		31,192		21,960	9,662	31,622				31,273	13,760	45,033
30 Planning Engineering and Design	*27.5%*	5,957	2,621	44.0%	8,578	1.8%	6,061	2,667	8,728		2031-1Q	115.5%	12,835	5,647	18,482
Planning Engineering and Design	*Total*	5,957	2,621		8,578		6,061	2,667	8,728				12,835	5,647	18,482
31 Construction Management (S&A)	*10.5%*	2,274	1,001	44.0%	3,275	1.8%	2,314	1,018	3,333		2032-4Q	135.9%	5,366	2,361	7,727
Construction Management	*Total*	2,274	1,001		3,275		2,314	1,018	3,333				5,366	2,361	7,727
L-31N Seepage Barrier Cutoff Wall In L-31N Levee just South of Tamiami Trail	*Total*	29,892	13,153		43,045		30,335	13,347	43,683				49,474	21,768	71,242

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ-Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: S-346 2-72" metal culvert w/Flash Board Removal 165 CFS in Old Tamiami Trail		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
15 FLOODWAY CONTROL & DIVERSION STRUC.		108	48	44.0%	156	1.3%	109	48	157		2031-1Q	39.5%	151	66	217
Construction Activities	*Total*	108	48		156		109	48	157				151	66	217
30 Planning Engineering and Design	27.5%	30	13	44.0%	43	1.8%	30	13	44		2030-1Q	104.9%	61	27	88
Planning Engineering and Design	*Total*	30	13		43		30	13	44				61	27	88
31 Construction Management (S&A)	10.5%	11	5	44.0%	16	1.8%	12	5	17		2031-1Q	115.5%	24	11	35
Construction Management	*Total*	11	5		16		12	5	17				24	11	35
S-346 2-72" metal culvert w/Flash Board Removal 165 CFS in Old Tamiami Trail	*Total*	149	66		215		151	66	218				236	104	340

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ-Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: L-67A Spoil Mounds in the Vacinity of S-631, 632, 633		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
11 LEVEES & FLOODWALLS		3,106	1,367	44.0%	4,473	1.4%	3,149	1,385	4,534		2025-2Q	25.4%	3,894	1,713	5,607
Construction Activities	*Total*	3,106	1,367		4,473		3,149	1,385	4,534				3,894	1,713	5,607
30 Planning Engineering and Design	*27.5%*	854	376	44.0%	1,230	1.8%	869	382	1,252		2024-1Q	54.5%	1,320	581	1,901
Planning Engineering and Design	*Total*	854	376		1,230		869	382	1,252				1,320	581	1,901
31 Construction Management (S&A)	*10.5%*	326	143	44.0%	470	1.8%	332	146	478		2025-2Q	63.4%	533	234	767
Construction Management	*Total*	326	143		470		332	146	478				533	234	767
L-67A Spoil Mounds in the Vacinity of S-631, 632, 633	*Total*	4,286	1,886		6,172		4,350	1,914	6,264				5,747	2,529	8,275

Contract Footnote: All costs were rounded up to the nearest $1,000 prior to entering into the TPCS.

Location: Central and Southern Fl District: SAJ Jacksonville District

Contract Summary

WBS		ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: Cultural Resource		Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
18 **CULTURAL RESOURCE PRESERVATION Construction**		830	365	44.0%	1,195	.9%	837	368	1,206		2032-3Q	43.%%	1,187	522	1,709
18 **CULTURAL RESOURCE PRESERVATION Mitigation**		17,235	7,583	44.0%	24,818	.9%	17,388	7,651	25,039		2032-3Q	43.%	24,645	10,844	35,489
Construction Activities	*Total*	18,065	7,949		26,014		18,226	8,019	26,245				25,832	11,366	37,198
31 **Construction Management (S&A)**	10.5%	1,897	835	44.0%	2,731	1.8%	1,930	849	2,779		2032-3Q	132.8%	4,416	1,943	6,359
Construction Management	*Total*	1,897	835		2,731		1,930	849	2,779				4,416	1,943	6,359
Cultural Resource	*Total*	19,962	8,783		28,745		20,156	8,868	29,024				30,249	13,309	43,558

Contract Footnote: Assume all Cultural Resource work is completed evenly throughout the project prior to construction starting. Amounts provided from Amro Habib Jacksonville District e-mail dated 5/31/2013 at 1:44 PM.
All costs were rounded up to the n

Location: Central and Southern Fl District: SAJ -Jacksonville District

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Contract Summary

WBS	ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: HTRW Investigation	Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q Risk Based				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
32 **HTRW Investigation**	625	275	44.0%	900	1.3%	633	278	911		2032-3Q	43.5%	897	395	1,292
HTRW Investigation *Total*	625	275		900		633	278	911				897	395	1,292
HTRW Investigation *Total*	625	275		900		633	278	911				897	395	1,292

Contract Footnote: Assume all HTRW is completed evenly throughout the project prior to construction starting. Amounts provided from Lisa Gued Jacksonville District e-mail dated 5/23/2013 at 10:08 AM. All costs were rounded up to the nearest $1,000 pri

Location: Central and Southern Fl District: SAJ Jacksonville District

Contract Summary

WBS	ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: Adaptive Management	Est Preparation Date: 01-Jul-13 Est Price Level: 2013-1Q				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
	COST ($K)	Risk Based CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
Adaptive Management AM and BO	72,516	31,907	44.0%	104,423	1.3%	73,429	32,309	105,738		2032-3Q	43.5%	104,076	45,793	149,869
Construction Activities *Trend*	72,516	31,907		104,423		73,429	32,309	105,738				104,076	45,793	149,869
Adaptive Management *Trend*	72,516	31,907		104,423		73,429	32,309	105,738				104,076	45,793	149,869

Contract Footnote: Assume all adaptive management spent evenly throughout construction. Amounts provided from Amro Habib Jacksonville District e-mail dated 12/19/2013 at 1:53 PM. All costs were rounded up to the nearest $1,000 prior to entering into th

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Contract Summary

WBS	ESTIMATED COST				PROJECT FIRST COST *CONSTANT DOLLAR BASIS*				SPENT	TOTAL PROJECT COST (FULLY FUNDED)				
Contract: **Real Estate**	Est Preparation Date: 03-Jul-13 Est Price Level: 2014-1Q				Program Yr: 2014 Prog Level Date: 2014-1Q				as of:					
	Risk Based COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	*SPENT* ($K)	MID-PT (DATE)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
01 LANDS AND DAMAGES	32,341			32,341	.%	32,341		32,341		2014-1Q	.%	32,341		32,341
01 LANDS AND DAMAGES	2,987	1,314	44.0%	4,301	.%	2,987	1,314	4,301		2035-4Q	50.7%	4,501	1,980	6,481
Lands and Damages *Total*	35,328	1,314		36,642		35,328	1,314	36,642				36,842	1,980	38,822
Real Estate *Total*	35,328	1,314		36,642		35,328	1,314	36,642				36,842	1,980	38,822

Contract Footnote: Assume all real estate is acquired evenly throughout the project prior to construction starting. Amounts provided from Donald Nelson Jacksonville District e-mail dated 1/16/2014 at 5:24 AM. All costs were rounded up to the nearest $1

Location: Central and Southern Fl District: SAJ -Jacksonville District



US Army Corps
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Directory of Expertise for Civil Works
Cost Engineering

RISK MANAGEMENT PLAN (RMP)

Central and Southern Florida Comprehensive Everglades Restoration Program

CENTRAL EVERGLADES PLANNING PROJECT
FLORIDA

Prepared by:

U.S. Army Corps of Engineers
Cost Engineering, Jacksonville, FL

April 2014

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1. INTRODUCTION

1.1 Purpose:

This Risk Management Plan (RMP) presents the process for implementing the comprehensive and proactive management of risk as part of the overall management of the Central Everglades Planning Project Feasibility Report. Project Risk management is a project management tool to handle events that might adversely impact the program, thereby increasing the probability/likelihood of success. This RMP describes a management tool that will:

- Serve as a basis for identifying alternatives to achieve cost, schedule, and performance goals,
- Assist in making decisions on budget and funding priorities,
- Provide risk information for Milestone decisions, and
- Allow monitoring the health of the program as it proceeds.

The RMP describes methods for assessing (identifying and analyzing), prioritizing, and monitoring risk drivers; developing risk-handling approaches, and applying adequate resources to handle risk. It assigns specific responsibilities for these functions, and prescribes the documenting, monitoring, and reporting processes to be followed.

The four main building blocks of the risk management process are identification, assessment, response, and documentation. The CSRA process addresses the "identification" and "assessment" portions of the risk management process. The activities of "response" and "documentation" are PM and PDT management efforts to mitigate, monitor, and manage the risks throughout the life cycle of the project.

If necessary, this RMP will be updated at the following milestones: (1) following approval of the FCSA; (2) Congressional authorization for construction; (3) receipt of Construction General funding; or (4) concurrent with the review and update of other program plans.

1.2 Objectives:

The objectives of the risk management plan are:

To focus attention on minimizing threats to achievement of the project objectives.

To provide an approach for:

- Identifying and assessing risks.
- Determining cost-effective risk reduction actions.
- Monitoring and reporting progress in reducing risk.

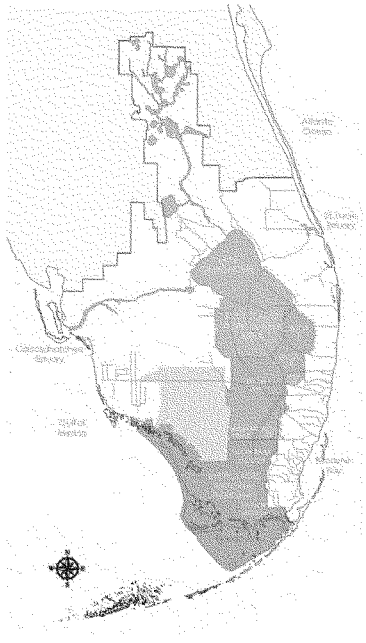
The overall goal of this process is to progressively reduce the project's exposure to events that threaten the accomplishment of its objectives by:

- Incorporating approaches into the project plans that minimize or avoid identified risks,
- Developing proactive, contingent risk response actions, and
- Rapidly implementing risk responses based on timely identification of risk occurrence.

2. PROJECT SUMMARY

2.1 Project Area Description

The study area for the CEPP encompasses the Northern Estuaries (St. Lucie River and Indian River Lagoon and the Caloosahatchee River and Estuary), Lake Okeechobee, the Everglades Agricultural Area (EAA), the Water Conservation Areas (specifically WCAs 2 and 3); ENP, the Southern Estuaries (specifically focused on Florida Bay), and portions of the Lower East Coast (LEC). Adjacent areas were also evaluated. For purposes of this study, the term Greater Everglades is defined as the region encompassing WCA 3 and ENP.



2.2 Project Scope

Features in the EAA include construction of the 14,000 acre A-2 FEB (L-624 perimeter levee and L-625 interior levee; C-624, C-624E, C-626 internal distribution channels; S-623, S-624, S-628 inlet structures; S-625 outlet structures, and C-625E, C-625W canals and channels connecting the FEB to the Miami Canal). Operation of the A-2 FEB would be integrated with the operation of the A-1 FEB, a state-funded and state-constructed FEB.

Conveyance features in WCA 2A and northern WCA 3A include: S-620 a gated culvert to deliver water from the L-6 Canal to the remnant L-5 Canal, S-622 a new gated spillway to deliver water from the remnant L-5 canal to the western L-5 canal (during L-6 diversion operations), S-621 a new gated spillway to deliver water from STA 3/4 to the S-7 pump station during peak discharge events (eastern flow route is not typically used during normal operations, including L-6 diversion operations, enlarge approximately 13.6 miles of the L-5 Canal, degrade approximately 2.9 miles of the southern L-4 Levee along the northwest boundary of WCA-3A, S-630 a 360 cfs pump station to maintain water supply deliveries west of the L-4 Canal, S-8A new gated culverts to deliver water from the Miami Canal (downstream of S-8, which pulls water from the L-5 Canal) to the L-4 Canal, and backfill approximately 13.5 miles of the Miami Canal and include upland mounds between a point approximately 1.5 miles south of the S-8 pump station and Interstate Highway I-75.

Additional conveyance features that would be located in southern WCA 3A, WCA 3B, and the northern edge of ENP include: S-333N a 1,150 cfs gated spillway adjacent to S-333, S-631 a 500 cfs gated culvert in L-67A Levee and an associated 6,000 foot gap in the L-67C Levee, a flowway through the western end of WCA 3B (S-632 and S-633 2 gated culverts in L-67A Levee, removal of approximately 8 miles of L-67C Levee, removal of approximately 4.3 miles of L-29 Levee, construct L-67D a new approximately 8.5 mile levee), S-355W a gated spillway in the L-29 Canal to maintain water deliveries in the L-29 Canal to the eastern Modified Water Deliveries (MWD) 1-mile bridge and maintain western access to the L-29 Levee, remove approximately 5.5 miles of the L-67 Extension Levee, and remove approximately 6 miles of Old Tamiami Trail between the Everglades National Park (ENP) Tram Road and the L-67 Extension Levee.

Features primarily for seepage management, which are required to mitigate for increased seepage include: S-356 a new 1,000 cfs pump station to replace the existing temporary S-356 pump station and a ~4.2 mile long, 35 feet deep tapering seepage barrier cutoff wall along the L-31N Levee just south of Tamiami Trail.

3. RISK-RELATED DEFINITIONS

The U.S. Army Corps of Engineers Cost Engineering Directory of Expertise for Civil Works (Cost Dx) recommends the following definitions for risk, as contained in current project and risk management guidance and literature, as noted.

3.1 **Risk:** An uncertain event or condition that, if it occurs, has a positive or negative effect on a project's objectives (source: PMBoK® Guide, p. 373).

3.1.1 Technical Risk: Risks having to do with product, process, or "technique" issues involved with designing and producing the deliverable (source: Project Risk Management, p. 78).

3.1.2 Cost Risk: The risk associated with the ability of the program to achieve its life cycle cost objectives (source: Defense Acquisition Deskbook).

3.1.3 Schedule Risk: Events or conditions that may have a negative influence on the project's timing (source: Risk Management Concepts and Guidance, p. 376).

3.1.4 Life-Safety Risk: Risk relating to the safety and/or security of human interests.

3.1.5 Reliability Risk: Risk relating to the performance and/or reliability of the system, product, or project feature being acquired.

3.1.6 Non-Technical Risk: Any risk that is not technical in nature and does not directly influence cost growth. Such risks would include organizational risks, political exposure, public relations issues, or potential loss of "goodwill" (public trust).

3.1.7 Internal Risk: An item or activity upon which the PDT has control or influence.

3.1.8 External Risk: An item or activity upon which the PDT has no control or influence.

3.2 **Risk Management:** Project Risk Management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project; most of these processes are updated throughout the project (source: PMBoK® Guide, 3rd edition, p. 237).

3.3 **Risk Analysis:** Qualitative or quantitative evaluations of the potential impact and probability of project risk events (source: Risk Management Concepts and Guidance, p. 373).

3.3.1 Qualitative Risk Analysis: Prioritizing risks for subsequent further analysis or action by assessing and combining their probability of occurrence and impact (source: PMBoK® Guide, 3rd edition, p. 237).

3.3.2 Quantitative Risk Analysis: Numerically analyzing the effect on overall project objectives of identified risks (source: PMBoK® Guide, 3rd edition, p. 237).

3.3.3 Cost and Schedule Risk Analysis (CSRA): Technique used to improve the development of contingencies by studying the variance of project cost caused by the effects of cost and schedule risk events. This process relies on qualitative and quantitative (e.g. Monte Carlo simulation) risk analysis techniques. CSRA is required on projects costs anticipated to be $40 Million or higher.

3.4 **Risk Communication:** Exchange or sharing of information about risk between the decision-maker, often the project manager, and other stakeholders (source: Project Risk Management Guidelines, p. 372).

3.5 **Risk Response Planning/Mitigation:** Developing options and actions to enhance opportunities, and to reduce threats to project objectives (source: PMBoK® Guide, 3rd edition, p. 237).

3.6 **Risk Monitoring and Control:** Tracking identified risks, monitoring residual risks, identifying new risks, executing risk response plans, and evaluating their effectiveness throughout the project life cycle (source: PMBoK® Guide, 3rd edition, p. 237).

3.7 **Risk Register:** The document containing the results of the qualitative risk analysis, quantitative risk analysis and risk response planning. The risk register details all identified risks, including description, category, cause, probability of occurring, impact(s) on objectives, proposed responses, owners, and current status (source: PMBoK® Guide, 4th edition, p. 439).

3.8 **Risk Trigger:** An indicator of the imminent occurrence of a given risk event that serves as an immediate precursor to the occurrence of the risk. Often used to initiate specific actions, behaviors, or responses (source: Risk Management Concepts and Guidance, p. 376).

3.9 **Watch List:** A list of major risks examined at each project risk review meeting (source: Project Risk Management Guidelines, p. 372).

4. RISK MANAGEMENT STRATEGY

The *Central Everglades Planning Project* risk management strategy is to handle program risks, both technical and non-technical, before they become problems, causing serious cost, schedule, or performance impacts. This strategy is an integral part of project success, and will be executed primarily through the Government Project Delivery Team (PDT). The PDT will continuously and proactively assess critical areas to identify and analyze specific risks and will develop options to mitigate all risks designated as moderate and high.

The PDT will keep risk information current by maintaining the risk register described in paragraph 6.2.4. Risk status will be reported at all project milestone reviews.

5. RESPONSIBILITIES AND ASSIGNMENTS

Over the course of the project, the Project manager may make specific assignments to individual members of the PDT, within their functional areas, to provide updates or input to the risk register. Table 1 below lists the general assignments and responsibilities:

Table 1-Risk Management Responsibilities

Task	Lead	Support
Risk Management Planning	PM	Cost Dx
Risk Identification	PM	PDT
Risk Analysis and Quantification	Cost Dx	PDT
Risk Response/Mitigation Plan	PM	PDT
Risk Monitoring and Control	PM	PDT
Risk Communication	PM	PDT
Risk Documentation/Closeout	PM	PDT

6. RISK MANAGEMENT PROCESS AND PROCEDURES

Led by the project manager, the PDT will conduct risk management activities to address those risks that are pertinent to the project. The project manager will employ the assistance of members of the PDT, project sponsors/customers and other subject matter experts as appropriate.

Overview of Project Risk Management Activities

- Risk Management Planning
- Risk Identification
- Risk Analysis and Quantification
- Risk Response Planning and Mitigation
- Risk Monitoring and Control
- Risk Communication
- Risk Documentation/Closeout

6.1 Risk Management Planning

Risk Management Planning will occur in conjunction with the development of the Project Management Plan (PMP) and will culminate with the approval of the Risk Management Plan (RMP). The RMP will present the strategy for procedures for identifying, analyzing, responding to, and monitoring risk throughout the project life cycle. The RMP will include treatment for both technical and non-technical risks, as well as risks that affect the project cost and schedule performance. Per ER 1110-2-1302 and ETL 1110-2-573, this project has undergone a formal Cost and Schedule Risk Analysis (CSRA) and the team will perform periodic updates..

6.2 Risk Identification

6.2.1 Initial Risk Discussions

Identification of risks will be accomplished through brainstorming sessions held with the PDT and project stakeholders. The PDT brainstorming session is the initial attempt to develop the risk register that serves as the basis for both the risk register development and the CSRA.

6.2.2 PDT Coordination

The PM will coordinate an initial risk discussion meeting, also referred to as a PDT brainstorming session. This is the first meeting where the PDT attempts to collectively

capture the project risks and place them into the risk register. The brainstorming session will include the major PDT members.

6.2.3 PDT Brainstorming Session

The PDT brainstorming session is the opportunity to bring the PDT together to qualitatively define the risk concerns as well as potential opportunities. As the concerns are discussed, the facilitator or risk analyst begins developing the initial risk register, capturing the PDT's concerns and discussions.

6.2.4 Risk Level

Each identified risk will be assigned a risk rating based on the joint consideration of event probability/likelihood and consequence/impact (see the Probability vs. Impact Risk Matrix below in Figure 1). This rating is a reflection of the severity of the risk and provides a starting point for the development of options to handle the risk. Probabilities are described as, VERY UNLIKELY, UNLIKELY, LIKELY, or VERY LIKELY. Impacts are described as, NEGLIGIBLE, MARGINAL SIGNIFICANT, CRITICAL, or CRISIS. Risk levels are described as, LOW, MODERATE, or HIGH.

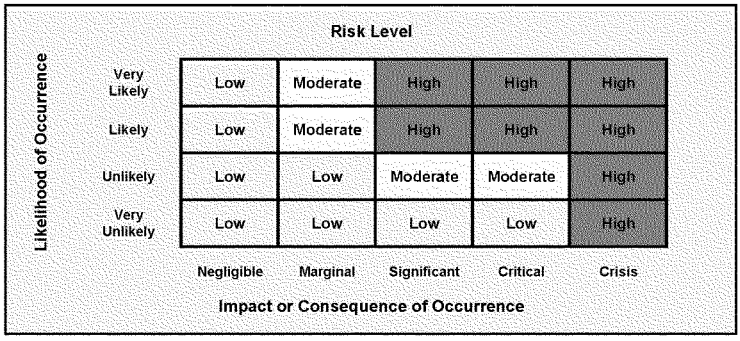
It is important to consider both the probability/likelihood and consequences/impacts in establishing the rating, as there may be risk events that have a low probability/likelihood, but whose consequences/impacts are so severe that the occurrence of the event would be disastrous to the project.

6.2.5 Completing Initial Risk Register

The risk register will serve as the basis for risk management, including the CSRA process. When referring to the risk register, the PDT should focus on the following:

- Risk/Opportunity – *Event.*
- PDT Event Concerns – *Describe the risk event.*
- PDT Discussions – *List the implications or any relevant background for this risk.*
- Responsibility/POC – *List who should have the action on the status of this risk.*
- Likelihood – *Describe the likelihood of this risk occurring, using VERY UNLIKELY, UNLIKELY, LIKELY, or VERY LIKELY.*
- Impact – *Describe the impact of this risk if it occurs, using NEGLIGIBLE, MARGINAL SIGNIFICANT, CRITICAL, or CRISIS.*
- Risk Level – *Determine the risk level according to the matrix below, using LOW, MODERATE, or HIGH.*

Figure 1-Probability vs. Impact Risk Matrix



The PDT should capture all concerns for all project features even if the risk level is considered low. The register serves as an archive of discussions and there is potential that low-level risks may become higher following market studies, more information being made available, or over time during the risk management and mitigation processes.

Within the risk register, the PDT concerns and discussions must be adequately and clearly captured, because the logic presented in those discussions must support the "likelihood" and "impact" decisions reflected within the risk register. While this product is the initial risk register, it has already captured the PDT's greatest concerns. The PDT can begin using this data to prepare for project risk management.

6.3 Risk Analysis

Risk analysis includes both qualitative and quantitative techniques to determine the key drivers of risk. Qualitative risk analysis shall occur on all risks, both technical and non-technical. The Project Risk "Watch List" will incorporate all risks identified as "Moderate" or "High" by qualitative analysis. All risks determined to have cost and/or schedule impacts and rated as "Moderate" or "High" will be quantitatively studied through the CSRA process. The PDT will enlist the support of the Cost Engineering Dx for completion of the CSRA process.

6.3.1 Qualitative Risk Analysis

Qualitative risk analysis will be conducted on all project risks, utilizing the collective judgment of the PDT and project stakeholders. Qualitative analysis will occur simultaneously to the completion of the initial risk register. Additionally, the qualitative analysis will be updated as the risks change throughout the project life cycle. Changes to the status of risks shall be captured by the project risk register at each monthly risk review meeting.

6.3.2 Quantitative Risk Analysis

Quantitative analysis will be conducted on all risks qualitatively rated as MODERATE or HIGH that affect cost and/or schedule performance. Quantitative analysis shall be conducted using the Monte Carlo technique with the support of the Cost Engineering Dx. Other risks may also be studied quantitatively, as directed. The results of the quantitative analysis will be presented in a final report and will include identification of the key drivers of risk for cost and schedule. The results of the quantitative analysis will include recommended levels for contingency and management reserve for completion of the project through implementation.

6.3.3 Cost and Schedule Risk Analysis (CSRA)

The CSRA will be performed in accordance with ER 1110-2-1302, ETL 1110-2-573, and Cost and Schedule Risk Analysis Guidance published by the Cost Engineering Dx. The project will utilize the Cost Engineering Dx for performance of the CSRA, using Crystal Ball software. At a minimum, the CSRA will include but not be limited to:

Review of planning, design and/or construction contract documents:

- Deliverables and work processes
- Milestones and schedule dates
- Resource estimates/needs/sources
- Performance requirements

Discussions and brainstorming activities with PDT members, appropriate takeholders/sponsor representatives and other qualified/knowledgeable individuals to develop a comprehensive list of risks for this project, referred to as the Risk Register.

Investigation of the various sources and symptoms of risks to aid in subsequent determination of risk controllability and selection of appropriate risk response actions.

The guidance and processes recommended to perform an acceptable cost and schedule risk analysis (CSRA) that meets Headquarters (HQ), U.S. Army Corps of Engineers (USACE) requirements and successfully passes an agency technical review (ATR) can be found at *http://www.nww.usace.army.mil/html/OFFICES/Ed/C/default.asp*.

6.3.4 Risk Prioritization

The PM and the PDT will prioritize the MODERATE and HIGH risks in their disciplines or functional areas. This prioritization will provide the basis for the development of risk handling plans and the allocation of risk management resources. Prioritization will be

accomplished using expert opinion within the PDT, and will be based on the following criteria:

- Risk Rating – MODERATE to HIGH
- Consequence/Impact – Within each rating, the highest value of consequence/impact
- Urgency – How much time is available before risk-handling actions must be initiated
- Probability/Likelihood – Within each rating, the highest value

The PDT will review the prioritized list of developed risks, and integrate them into a single list of prioritized project risks, using the same criteria.

6.4 Risk Response Planning and Mitigation

Following initial identification and analysis of risks, the PDT will develop an approach for risk handling for all key drivers of risk, including each MODERATE and HIGH risk. For all such risks, the various handling techniques should be evaluated in terms of feasibility, expected effectiveness, cost and schedule implications, and the effect on the project's performance. Risk responses will also include an accompanying "fallback" plan if the primary treatment strategy is not effective at mitigating the impact of risk. Reducing requirements as a risk avoidance technique will be used only as a last resort, and then only with the participation and approval of District and Division Management.

In addition to developing approaches for handling each MODERATE and HIGH risk, the following will act as risk triggers requiring an immediate response and mitigation plan:

- Cost growth greater than 1% of the estimated project cost
- Schedule delays greater than 3 months
- Potential for significant damage to private or public property
- Potential for injury or loss of life
- Potential to generate media coverage (either positive or negative)
- Potential environmental degradation or release of deleterious substances
- Potential to alter political or stakeholder support

The results of the evaluation and selection will be included and documented. This documentation will include the following elements:

- What must be done,
- List of all assumptions,
- Level of effort and resources required,
- Resources needed that are outside the expertise of the PDT,
- Estimated cost to implement the plan,

- Proposed schedule showing the proposed start date, the time phasing of significant risk reduction activities, the completion date, and their relationship to significant project activities/milestones,
- Recommended metrics for tracking risk-handling activity,
- Considerations for secondary or residual risks implications, and
- Person responsible for implementing and tracking the selected option.

6.5 Risk Monitoring and Control

Risk monitoring is the systematic tracking and evaluation of the progress and effectiveness of risk-handling actions by the comparison of predicted results of planned actions with the results actually achieved to determine status and the need for any change in risk-handling actions. The Project Manager and the PDT will monitor all identified risks in their disciplines or areas, with particular attention to those risks rated as MODERATE OR HIGH.

6.5.1 Monitor Risk Status

As work is performed on the project, the PDT will monitor and assess:

- Progress in reducing risk,
- Occurrence of risks that call for initiation of contingent risk responses,
- Effectiveness of implemented risk reduction actions and any needs to modify these actions.

Risk status will be updated immediately when risks change and upon the completion of a project milestone. The status of the risks and the effectiveness of the risk-handling actions will be agenda items for all design and program reviews, and will be reported to the PM on the following occasions:

- Monthly,
- When the PDT determines that the status of the risk area has changed significantly (as a minimum when the risk changes from high to moderate to low, or vice versa),
- When requested by Management.

There are a number of techniques and tools available for monitoring the effectiveness of risk-handling actions. At a minimum, the PM and PDT will use the Risk Register and Watch List for day-to-day management and monitoring of risks.

MODERATE or HIGH risks will be monitored by the PM until the risk is considered LOW and recommended for "Close Out." Functional area leads will continue to monitor LOW

risk events in their areas to ensure that appropriate risk-handling action can be initiated if there are indications that the rating may change.

6.5.2 Maintenance of Project Risk Register

Throughout the life cycle of the project, the PDT will update the Risk Register to reflect the results of monitoring risk status. This list will also reflect the effect of any project re-planning changes and/or change controls. Updates shall be made monthly to the risk register. Any changes to risk status upon event occurrence or completion of a project milestone will also be captured immediately on the risk register.

The Risk Register will be discussed at project team meetings and specific risks of concern should be elevated to the Pre-PRB, PRB and/or project sponsors as appropriate.

6.5.3 Maintenance of Project Watch List

Throughout the life cycle of the project, the PM and the PDT will maintain a project watch list to reflect the results of monitoring risk status. The watch list, at a minimum, will contain the:

- Potential Risk Event,
- Planned Risk Reduction Actions,
- Point of Contact/Assignment,
- Due Date, and
- Status.

6.6 Risk Communication

Risk communication is essential to actively managing risks throughout the project life cycle. Communication begins with the preparation of the Risk Management Plan and continues through project closeout. Subsequently, the preparation of the project risk register facilitates communication of risks at all levels. The Cost Engineering Dx will also prepare a report regarding the formal CSRA process to be incorporated within the Cost Appendix to the Engineering Appendix of the Feasibility Report.

The PDT will review the risk register monthly to provide visibility of risks and progress in mitigating them. If necessary, risk occurrences will be elevated to the Pre-PRB, PRB and/or project sponsors for their attention (note "internal" vs. "external" risks).

The following risk triggers, as contained in paragraph 6.4 above, shall prompt the immediate communication of risks to Management:

- Cost growth greater than 1% of the estimated project cost
- Schedule delays greater than 3 months
- Potential for significant damage to private or public property
- Potential for injury or loss of life
- Potential to generate media coverage (either positive or negative)
- Potential environmental degradation or release of deleterious substances
- Potential to alter political or stakeholder support

6.7 Risk Documentation and Closeout

When the project reaches the closeout phase, the PM and the PDT will document the final results of the execution of the Risk Management Plan for inclusion in the final project records and the District and/or Enterprise Lessons Learned database. At a minimum, this information will include risk assessment documents (including the risk register), risk-handling plans (including the project watch list), contract deliverables, if appropriate, and any other risk-related reports.

US Army Corps
of Engineers®
Walla Walla District

Central and Southern Florida Comprehensive Everglades Restoration Program - Central Everglades Planning Project

P2 Project Number 370939

Project Cost and Schedule Risk Analysis Report

Prepared in partnership between:

U.S. Army Corps of Engineers,
Jacksonville District

and

U.S. Army Corps of Engineers,
Cost Engineering Technical Center of Expertise for Civil Works (TCX)
Walla Walla District

25 Feb 2014

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APPENDIX

Appendix A - Risk Register and Model

EXECUTIVE SUMMARY

Through a partnership between the U.S. Army Corps of Engineers (USACE), Jacksonville District, and the USACE, Cost Engineering TCX, this report presents a recommendation for the total project cost and schedule contingencies for the Central Everglades Planning Project, Florida. In compliance with Engineer Regulation (ER) 1110-2-1302, Civil Works Cost Engineering, dated 15 September 2008, a formal risk analysis study was conducted for the development of contingency on the total project cost. The purpose of this risk analysis study was to establish project contingencies by identifying and measuring the cost and schedule impact of project uncertainties with respect to the estimated total project cost.

Specific to the Central Everglades Planning Project, the most likely total of First Costs cost is estimated at $1,900,269,000. Based on the results of the analysis, the USACE Cost Engineering TCX recommends a contingency value of $570,756,000 for construction or 44 percent.

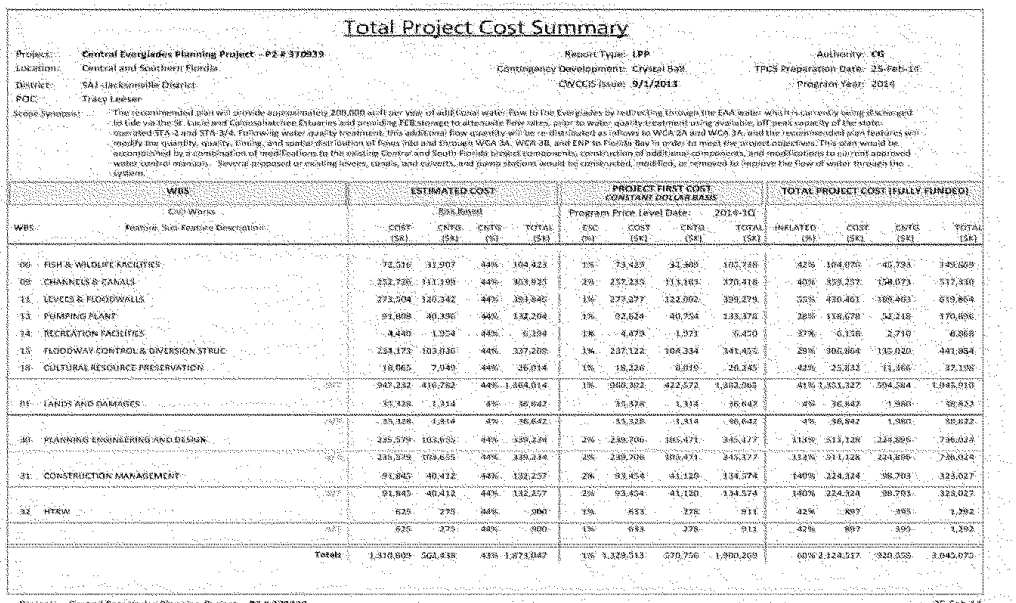
The Cost Engineering TCX performed risk analysis using the *Monte Carlo* technique, producing the aforementioned contingencies and identifying key risk drivers.

The following Table ES-1 portrays the development of contingencies for the project. The contingency is based on an 80 percent confidence level, as per USACE Civil Works guidance.

Table ES-1 portrays the full costs of the recommended alternative based on the anticipated acquisition approach. The costs are intended to address the congressional request of estimates to implement the project. The contingency is based on an 80 percent confidence level, as per accepted USACE Civil Works guidance. Note that there is approximately $32M in Real Estate costs for lands already acquired with Federal funds that are included in the 01 account.

Table ES-1. Total Project Cost Summary

Notes:
1) Costs include all contingencies and escalation, supported by a risk analysis
2) Costs exclude O&M and Life Cycle Cost estimates



Total Project Cost Summary

Project: **Central Everglades Planning Project - P2 # 370939** | Report Type: **LPP** | Authority: **CG**
Location: Central and Southern Florida | Contingency Development: Crystal Ball | TPCS Preparation Date: 25-Feb-14
District: SAJ-Jacksonville District | CWCCIS Issue: **9/1/2013** | Program Year: 2014
POC: Tracy Leeser

Scope Synopsis: The recommended plan will provide approximately 200,000 acft per year of additional water flow to the Everglades by redirecting through the EAA water which is currently being discharged to tide via the St. Lucie and Caloosahatchee Estuaries and providing FEB storage to attenuate flow rates, prior to water quality treatment using available, off-peak capacity of the state-operated STA-2 and STA 3/4. Following water quality treatment, this additional flow quantity will be re-distributed as follows to WCA 2A and WCA 3A, and the recommended plan features will modify the quantity, quality, timing, and spatial distribution of flows into and through WCA 3A, WCA 3B, and ENP to Florida Bay in order to meet the project objectives. This plan would be accomplished by a combination of modifications to the existing Central and South Florida project components, construction of additional components, and modifications to current approved water control manuals. Several proposed or existing levees, canals, and culverts, and pump stations would be constructed, modified, or removed to improve the flow of water through the system.

WBS		ESTIMATED COST (Fish Kissee)				PROJECT FIRST COST (CONSTANT DOLLAR BASIS) Program Price Level Date: 2014-1Q				TOTAL PROJECT COST (FULLY FUNDED)			
Civil Works WBS	Feature, Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
06	FISH & WILDLIFE FACILITIES	72,516	31,907	44%	104,423	1%	73,429	31,909	105,738	42%	104,076	45,793	149,869
08	CHANNELS & CANALS	252,726	111,199	44%	363,925	2%	257,235	113,183	370,418	40%	358,257	158,073	517,330
11	LEVEES & FLOODWALLS	273,504	120,342	44%	393,846	1%	277,277	122,002	399,279	55%	430,461	189,403	619,864
13	PUMPING PLANT	91,808	40,396	44%	132,204	1%	92,624	40,754	133,378	28%	118,678	52,218	170,896
14	RECREATION FACILITIES	4,448	1,958	44%	6,406	1%	4,473	1,973	6,450	37%	6,156	2,710	8,866
15	FLOODWAY CONTROL & DIVERSION STRUC	234,173	103,036	44%	337,208	1%	237,122	104,334	341,455	29%	306,864	135,020	441,884
18	CULTURAL RESOURCE PRESERVATION	18,065	7,949	44%	26,014	1%	18,226	8,019	26,245	42%	25,811	11,366	37,178
		947,232	416,782	44%	1,364,014	1%	960,302	422,572	1,382,968	41%	1,353,327	594,584	1,945,910
01	LANDS AND DAMAGES	33,328	1,314	4%	34,642		33,328	1,314	34,642	4%	34,842	1,980	36,822
		33,328	1,314	4%	34,642		33,328	1,314	34,642	4%	34,842	1,980	36,822
30	PLANNING ENGINEERING AND DESIGN	235,579	103,655	44%	339,234	2%	239,706	105,471	345,177	114%	511,128	224,896	736,024
		235,579	103,655	44%	339,234	2%	239,706	105,471	345,177	114%	511,128	224,896	736,024
31	CONSTRUCTION MANAGEMENT	91,845	40,412	44%	132,257	2%	93,454	41,120	134,574	140%	224,324	98,703	323,027
		91,845	40,412	44%	132,257	2%	93,454	41,120	134,574	140%	224,324	98,703	323,027
32	HTRW	625	275	44%	900	1%	633	278	911	42%	897	395	1,292
		625	275	44%	900	1%	633	278	911	42%	897	395	1,292
	Totals:	1,308,609	563,438	43%	1,873,047	1%	1,329,513	570,756	1,900,269	60%	2,124,517	920,559	3,045,076

Project: *Central Everglades Planning Project - P2 # 370939* 25-Feb-14

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

There are several risks in this project that are beyond the team's ability to assess and identify that cannot be modeled effectively. The complexity of the numerous overlapping projects in the project area and their range of outcomes could result in a complete reformulation of the project based on their results, any changing legal interpretations, and or unforeseen environmental effects of these other projects. These risks are noted to carry in the project risk register for monitoring, but not specifically modeled as their impact could result in a major reformulation of the project.

The key risk drivers well as potential for key cost risk drivers identified through sensitivity analysis are P-PPM-4 Funding Profile, EST-12 Estimate Assumptions/Design of Structures, NR-TL-4 FEB spreader canal length, and SR-TL-7 S-8 Pump station design. Other significant risks are FEB rock porosity and Fuel Costs.

-Discussions:

It should be noted that the Crystal Ball Sensitivity model displays items with the largest potential range of costs as being the most sensitive. However depending on the model construction these items with large ranges may not have as large of contribution to the actual contingency as items with much smaller ranges.

P-PPM-4- Funding Profile- The base funding is on a constant dollar $100M/year expenditure schedule. The project was scheduled in an optimum order to maintain flood control and minimize the requirement of offsite borrow. Changing the funding levels can impact the cost and schedule duration significantly due to changes in the number of contracts, administration costs, borrow/fill balance, and unforeseen intermediate work between project stages.

EST-12 Estimate Assumptions/Design of Like Similar Structures- The estimate utilizes a corollary approach to utilize recently constructed similar features in the area to determine the scope and quantities for the proposed features. As the structures are designed as the project moves forward, the scope and sizing could vary significantly from the assumed structure resulting in cost changes.

NR-TL-4 FEB Spreader Canal Length- The final size and length of the spreader canal could range in cost over 100M depending on the final dimensions. This may not be known until further investigations are conducted specifically in this area, and may be subject to changes due to

S-8 Pump Station Design- The need to update or replace the flood control pump station at S-8 is unclear at this time. The station could require simple modifications to a complete replacement. This uncertainty could cause a $100M increase in the project cost if a new station and associated canals is required.

The key schedule risk driver identified through sensitivity analysis is the Project and Program MGMT Risk P-PPM-4 (Funding Profile), which contributes 58% percent of the statistical schedule variance. Other significant schedule risks include the project size requiring multiple overlapping projects, the risk of getting an approved project report and the corresponding start of the Preconstruction, Engineering, and Design Phase (PED), as well as technical risks regarding the physical construction feature size, cost, and construction duration, I.e. the FEB spreader canal length and the overall design assumptions in the cost estimate.

-Discussions:

P-PPM-4 The base funding is on a $100M/year construction schedule for the assumed project schedule. Changing the annual level of funding amount will change the duration significantly from what is assumed. This could change the assumption in construction order and required a different work approach in some phases of the construction.

The other remaining schedule risks can directly impact the project cost causing the construction to run longer due to the $100m annual cap assumed as well as physically extending the construction duration due to increased quantities.

Recommendations, as detailed within the main report, include the development of an integrated Risk Management Plan, management of design and construction within established contingency ranges as well as and further iterative study of risks throughout the project life cycle to include; potential mitigation throughout the planning, engineering, and design phase; and proactive monitoring and control of risk identified in this study.

1.0 PURPOSE

Through a partnership between the U.S. Army Corps of Engineers (USACE), Jacksonville District, and the USACE, Cost Engineering TCX, this report presents a recommendation for the total project cost and schedule contingencies for the Central Everglades Planning Project, Florida.

2.0 BACKGROUND

The recommended plan will provide approximately 200,000 ac-ft per year of additional water flow to the Everglades by redirecting through the EAA water which is currently being discharged to tide via the St. Lucie and Caloosahatchee Estuaries and providing FEB storage to attenuate flow rates, prior to water quality treatment using available, off-peak capacity of the state-operated STA-2 and STA-3/4. Following water quality treatment, this additional flow quantity will be re-distributed as inflows to WCA 2A and WCA 3A, and the recommended plan features will modify the quantity, quality, timing, and spatial distribution of flows into and through WCA 3A, WCA 3B, and ENP to Florida Bay in order to meet the project objectives. This plan would be accomplished by a combination of modifications to the existing Central and South Florida project components, construction of additional components, and modifications to current approved water control manuals. Several proposed or existing levees, canals, and culverts, and pump stations would be constructed, modified, or removed to improve the flow of water through the system.

As a part of this effort, Jacksonville District requested the USACE Cost Engineering Directory of Expertise for Civil Works (Cost Engineering TCX) to develop the cost estimate and schedule for the recommended project plan. This task also included performing a cost and schedule risk analysis to identify the amount of contingency that must be added to the cost estimate to reduce the uncertainty to an acceptable level to ensure that reasonable costs can be developed for the identified project features.

3.0 REPORT SCOPE

The scope of the project cost and schedule risk analysis report is to calculate and present the cost and schedule contingencies at the 80 percent confidence level using the risk analysis processes, as mandated by U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter (ETL) 1110-2-573, Construction Cost Estimating Guide for Civil Works. The report presents the contingency results for cost and schedule risks for all project features, but does not include consideration for life cycle costs. The formal process included extensive involvement of the PDT for risk identification and development of the risk register. The analysis process evaluated the most likely Micro Computer Aided Cost Estimating System (MCACES) cost estimate, schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in ETL 1110-2-573.

The project technical scope was developed by the Jacksonville District, the estimates, and schedules were developed and presented by the Walla Walla District. These documents serve as the basis for the risk analysis.

The scope of this study addresses the identification of problems, needs, opportunities, and potential solutions that are viable from an economic, environmental, and engineering viewpoint.

3.1 Project Scope

Features in the EAA (North of the Redline) include construction of the 14,000 acre A-2 FEB (L-624 perimeter levee and L-625 interior levee; C-624, C-624E, C-626 internal distribution channels; S-623, S-624, S-628 inlet structures; S-625 outlet structures, and C-625E, C-625W canals and channels connecting the FEB to the Miami Canal). Operation of the A-2 FEB would be integrated with the operation of the A-1 FEB, a state-funded and state-constructed FEB.

Conveyance features in WCA 2A and northern WCA 3A (South of the Redline) include: S-620 a gated culvert to deliver water from the L-6 Canal to the remnant L-5 Canal, S-622 a new gated spillway to deliver water from the remnant L-5 canal to the western L-5 canal (during L-6 diversion operations), S-621 a new gated spillway to deliver water from STA 3/4 to the S-7 pump station during peak discharge events (eastern flow route is not typically used during normal operations, including L-6 diversion operations, enlarge approximately 13.6 miles of the L-5 Canal, degrade approximately 2.9 miles of the southern L-4 Levee along the northwest boundary of WCA-3A, S-630 a 360 cfs pump station to maintain Seminole Tribe water supply deliveries west of the L-4 Canal, S-8A new gated culverts to deliver water from the Miami Canal (downstream of S-8, which pulls water from the L-5 Canal) to the L-4 Canal, and backfill approximately 13.5 miles of the Miami Canal and include upland mounds between a point approximately 1.5 miles south of the S-8 pump station and Interstate Highway I-75.

Additional conveyance features that would be located in southern WCA 3A, WCA 3B, and the northern edge of ENP (Blue Green line) include: S-333N a 1,150 cfs gated spillway adjacent to S-333, S-631 a 500 cfs gated culvert in L-67A Levee and an associated 6,000 foot gap in the L-67C Levee, a flowway through the western end of WCA 3B (S-632 and S-633 2 gated culverts in L-67A Levee, removal of approximately 8 miles of L-67C Levee, removal of approximately 4.3 miles of L-29 Levee, construct L-67D a new approximately 8.5 mile levee), S-355W a gated spillway in the L-29 Canal to maintain water deliveries in the L-29 Canal to the eastern Modified Water Deliveries (MWD) 1-mile bridge and maintain western access to the L-29 Levee, remove approximately 5.5 miles of the L-67 Extension Levee, and remove approximately 6 miles of Old Tamiami Trail between the Everglades National Park (ENP) Tram Road and the L-67 Extension Levee. Work in this area also includes removal of spoil along the western L-67A canal in the vicinity of the new control structures and removal of vegetation along WCA-3B agricultural ditches.

Features primarily for seepage management (Yellowline), which are required to mitigate for increased seepage resultant from the Blue Green line features include: S-356 a new 1,000 cfs pump station to replace the existing temporary S-356 pump station and a ~4.2 mile long, 35 feet deep tapering seepage barrier cutoff wall along the L-31N Levee just south of Tamiami Trail.

To address quality, quantity, timing and distribution of the water through the CEPP project various types of infrastructure were considered during the formulation process such as: Stormwater Treatment Areas (STAs), a Flow Equalization Basin (FEB), deep storage reservoir, spreader canals, pumps, canal backfilling and canal plugs, levee removal and levee gaps, culverts/gated structures, seepage barrier walls, seepage control pumps, hydraulic ridge detention areas, and step down levees.

3.2 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements, as well as the guidance provided by the Cost Engineering TCX. The risk analysis process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, cost and schedule risk analysis should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, cost estimating, budgeting, and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, this risk analysis was performed to meet the requirements and recommendations of the following documents and sources:

- Cost and Schedule Risk Analysis Guidance prepared by USACE Cost Engineering TCX.
- ER 1110-2-1302, Civil Works Cost Engineering, dated 15 September 2008.
- ETL 1110-2-573, Construction Cost Estimating Guide for Civil Works, dated 30 September 2008.

4.0 METHODOLOGY / PROCESS

The Cost Engineering TCX assembled a team consisting of one senior civil cost engineer with support from other cost engineers from Walla Walla and staff from Jacksonville District to further augment labor, expertise, and information gathering. The Jacksonville staff included cost support from a cost engineering team, as well as coordination support from project management and the assigned PDT.

The Cost Engineering TCX cost engineer facilitated a risk identification and qualitative analysis meeting onsite with Jacksonville District from 4 - 8 February 2013. The initial risk identification meeting also included qualitative analysis to produce a risk register that served as the framework for the risk analysis. Subsequent additions and revisions to the risk register occurred between 18 – 19 April 2013 due to changing project assumptions and conditions. The risk register was sent for review and comments from the PDT and sponsor were incorporated at each revision.

Following multiple iterations of revision and refinement of the baseline estimate the Cost Engineering TCX conducted quantitative analyses for cost and schedule risks. The cost and schedule risk models were completed and results were reported initially on 3 July 2013. Based on Agency Technical Review (ATR) of the technical and cost documents, the risk analysis was revised at each iteration based on comments and revisions to the cost estimate.

The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve any desired level of cost confidence.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions, or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost Engineering TCX guidance for cost and schedule risk analysis generally focuses on the 80 percent level of confidence (P80) for cost contingency calculation. It should be noted that use of P80 as a decision criteria is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level. The selection of contingency at a particular confidence level is ultimately the decision and responsibility of the project's district and/or division management.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a

commercially available risk analysis software package (i.e., Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in section 6.0.

4.1 Identify and Assess Risk Factors

Identifying the risk factors via the PDT is considered a qualitative process that results in establishing a risk register that serves as the document for the quantitative study using the Crystal Ball risk software. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

Checklists or historical databases of common risk factors are sometimes used to facilitate risk factor identification. However, key risk factors are often unique to a project and not readily derivable from historical information. Therefore, input from the entire PDT is obtained using creative processes such as brainstorming or other facilitated risk assessment meetings. In practice, a combination of professional judgment from the PDT and empirical data from similar projects is desirable and is considered.

Formal PDT meetings are held for the purposes of identifying and assessing risk factors. The meetings should include capable and qualified representatives from multiple project team disciplines and functions, for example:

- Project/Program managers
- Contracting/acquisition
- Real Estate
- Relocations
- Environmental
- Civil and Coastal Design
- Cost and schedule engineers
- Construction
- Key Sponsors

The initial formal meetings should focus primarily on risk factor identification using brainstorming techniques, but also include some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Subsequent meetings should focus primarily on risk factor assessment and quantification.

Additionally, numerous conference calls and informal meetings are conducted throughout the risk analysis process on an as-needed basis to further facilitate risk factor identification, market analysis, and risk assessment.

4.2 Quantify Risk Factor Impacts

The quantitative impacts of risk factors on project plans were analyzed using a combination of professional judgment, empirical data, and analytical techniques. Risk factor impacts were quantified using probability distributions (density functions), because risk factors are entered into the Crystal Ball software in the form of probability density functions.

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. However, the quantification process relied more extensively on collaboration between cost engineering and risk analysis team members with lesser inputs from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- Maximum possible value for the risk factor
- Minimum possible value for the risk factor
- Most likely value (the statistical mode), if applicable
- Nature of the probability density function used to approximate risk factor uncertainty
- Mathematical correlations between risk factors
- Affected cost estimate and schedule elements

The resulting product from the PDT discussions is captured within a risk register as presented in Section 6 for both cost and schedule risk concerns. Note that the risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions are meant to support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

4.3 Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes, as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each

feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

5.0 PROJECT ASSUMPTIONS

The following data sources and assumptions were used in quantifying the costs associated with the with- and without-project conditions.

a. The MII MCACES (Micro-Computer Aided Cost Estimating Software) file "CEPP Master July 31 Updates v 4-2" was the basis for the cost and schedule risk analyses. The schedule was developed based on the durations of construction form the MII file durations developed in MS project and a funding limited schedule developed.

b. The cost comparisons and risk analyses performed and reflected within this report are based on early planning level design including like similar structures for scope to develop the estimates.

c. Per the EM 1110-2-1304, Civil Works Construction Cost Index System, historical state adjustment factor, for Florida is 0.93, meaning that this project is not as susceptible to differential between the local market and Office of Management and Budget inflation factors for future construction.

d. The Cost TCX guidance generally focuses on the 80 percent level of confidence (P80) for cost contingency calculation. For this risk analysis, P80 was used. It should be noted that the use of P80 as a decision criteria is a moderate risk adverse approach, generally resulting in higher cost contingencies. However, the P80 level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to capture actual project costs.

e. Only high and moderate risk level impacts, as identified in the risk register, were considered for the purposes of calculating cost contingency. Low-level risk impacts were only studied in the case of a schedule impact affecting the cost, although all low impact risks should be maintained in project management documentation and reviewed at each project milestone to determine if they should be placed on the risk "watch list" for further monitoring and evaluation.

6.0 RESULTS

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

6.1 Risk Register

A risk register is a tool commonly used in project planning and risk analysis. The actual risk register is provided in Appendix A. The complete risk register includes low-level risks, as well as additional information regarding the nature and impacts of each risk.

It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

6.2 Cost Contingency and Sensitivity Analysis

Table 1 provides the construction cost contingencies calculated for the P80 confidence level. The construction cost contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes only.

Contingency was quantified as approximately $422 Million at the P80 confidence level (44 percent of the baseline cost estimate). For comparison, the cost contingency at the P50 and P100 confidence levels was quantified as 33 percent and 78 percent of the baseline cost estimate, respectively.

Table 1. Estimate Cost Contingency Summary

Risk Analysis Forecast	Baseline Estimate (excluding 30/31 accounts)	Total Contingency[1,2] ($)	Total Contingency (%)
50% Confidence Level			
Project Cost	$961,252,700	$317,213,391	33%
80% Confidence Level			
Project Cost	$961,252,700	$422,951,188	44%
100% Confidence Level			
Project Cost	$961,252,700	$749,777,106	78%

Notes:
1) These figures combine uncertainty in the baseline cost estimates and schedule.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

6.2.1 Sensitivity Analysis

Sensitivity analysis generally ranks the relative impact of each risk/opportunity as a percentage of total cost uncertainty. The Crystal Ball software uses a statistical measure (contribution to variance) that approximates the impact of each risk/opportunity contributing to variability of cost outcomes during *Monte Carlo* simulation. It should be noted that the Crystal Ball Sensitivity model displays items with the largest potential range of costs generally as being the most sensitive. However depending on the model construction these items with large ranges may not have as large of contribution to the actual contingency as items with much smaller ranges.

Analysis of the key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project life cycle. Together with the risk register, sensitivity analysis results can also be used to support development of strategies to eliminate, mitigate, accept, or transfer key risks.

6.2.2 Sensitivity Analysis Results

The risks/opportunities considered as key or primary cost drivers are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost are shown with a negative sign; risks are shown with a positive sign to reflect the potential to increase project cost. A longer bar in the sensitivity analysis chart represents a greater potential impact to total project cost.

Figure 1 presents a sensitivity analysis for cost growth risk from the high level cost risks identified in the risk register. Likewise, Figure 2 presents a sensitivity analysis for schedule growth risk from the high level schedule risks identified in the risk register.

6.3 Schedule and Contingency Risk Analysis

Table 2 provides the schedule duration contingencies calculated for the P80 confidence level. The schedule duration contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes.

Schedule duration contingency was quantified as 89 months based on the P80 level of confidence. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

Table 2. Schedule Duration Contingency Summary

Risk Analysis Forecast	Baseline Schedule Duration (months)	Contingency[1] (months)	Contingency (%)
50% Confidence Level			
Total Project Duration	329	63	19%
80% Confidence Level			
Total Project Duration	329	89	27%
100% Confidence Level			
Total Project Duration	329	162	49%

Notes:
1) A PERT type analysis was not completed on the schedule. The schedule was not resource loaded but was balanced between construction duration and annual funds availability. These issues should be considered as limitations in the utility of the schedule contingency data presented in Table 3.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

Figure 1. Cost Sensitivity Analysis

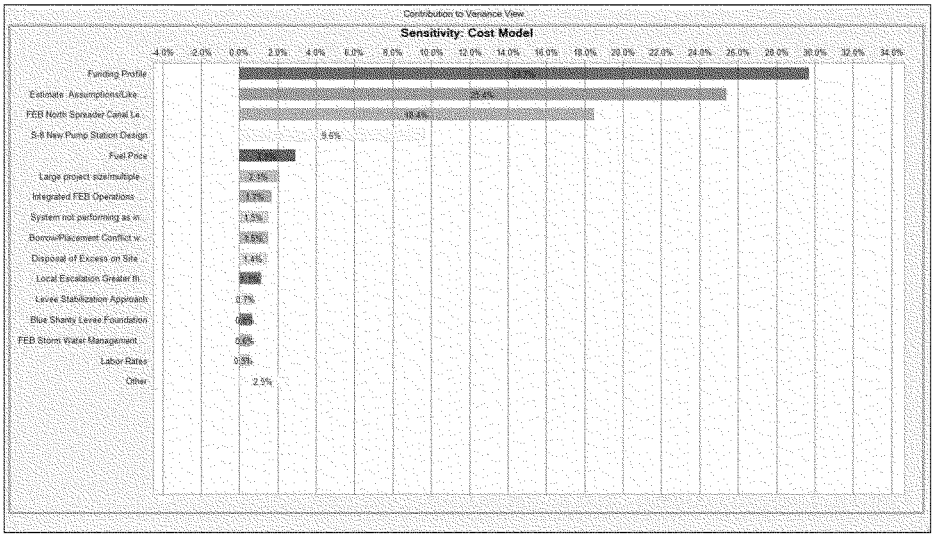
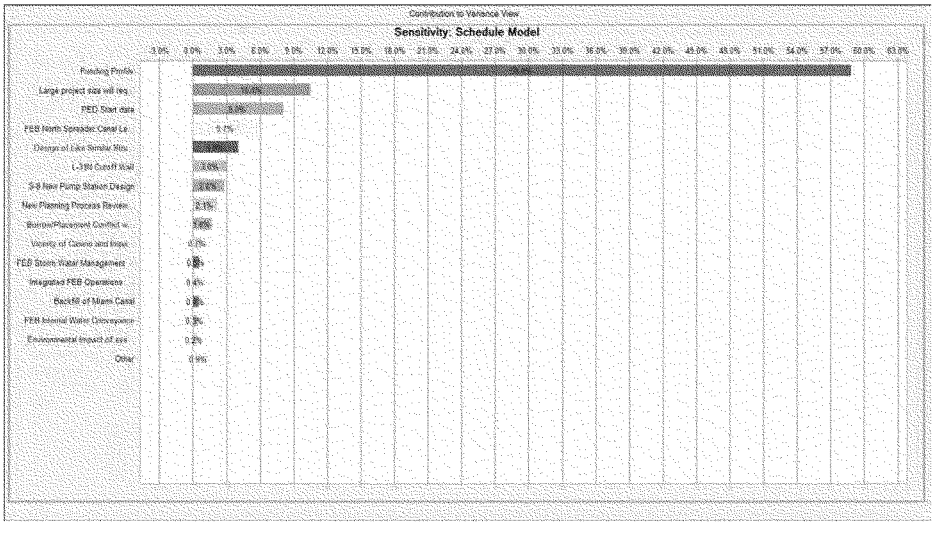


Figure 2. Schedule Sensitivity Analysis



7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

7.1 Major Findings/Observations

Total project cost comparison summaries are provided in Table 3 and Figure 3. Project duration summaries are provided in Figure 4. Operation and maintenance activities were not included in the cost estimate or schedules. Therefore, a full life-cycle risk analysis was not performed. Risk analysis results or conclusions could be significantly different if the necessary operation and maintenance activities were included.

Major findings and observations of the risk analysis are listed below.

7.1.1 COST RISK

There are several risks in this project that are beyond the team's ability to assess and identify that cannot be modeled effectively. The complexity of the numerous overlapping projects in the project area and their range of outcomes could result in a complete reformulation of the project based on their results, changing legal interpretations, and or unforeseen environmental effects from these other projects. These risks are noted to carry on the in the project risk register/ risk management plan for monitoring, but not specifically modeled. Changes in the project as a resultant of these risks should be carefully monitored to ensure the project can be successfully completed within authorized cost limits.

The key cost risk drivers identified through sensitivity analysis are P-PPM-4 Funding Profile, NR-TL-4 FEB spreader canal length, EST-12 Design of like Similar Structures, and SR-TL-7 S-8 Pump station design. Other significant risks are Fuel Cost and Borrow/Placement Conflict with Multiple Contracts.

P-PPM-4 Funding Profile - The base funding is on a $100M/year construction schedule. Changing the funding amount can change the duration significantly and cause the cost to vary due to changes in the number of contracts, administration costs, borrow/fill balance changes, and intermediate work between project stages to maintain flood control or prevent other loss and damage.

NR-TL-4 FEB Spreader Canal Length - The final size and length of the spreader canal could range in cost over 100M depending on the final dimensions. This may not be known until further investigations are conducted specifically in this area.

EST-12 Design of Like Similar Structures - The estimate utilizes a corollary approach to utilize recently constructed similar features in the area to determine the scope and quantities for the proposed features. As the structures are designed as the project moves forward, the scope and sizing could vary from the assumed structure resulting in different costs to execute. With respect to Estimate Development (Estimate and Schedule Risks EST-12), Cost TCX believes this risk will decline during planning, engineering, and design as detailed descriptions of work are developed and refined.

SR-TL-7 S-8 New Pump Station Design - The design of upgrade is unknown at this time. The pump station at a minimum is in need of upgrades to ensure that it will operate in the new system as intended. If not suitable, the station could require a complete replacement as well as a reconfiguration of the canals for intake and discharge. This could cause nearly a $100M impact to the project cost.

Fuel Prices - Fuel prices are ever fluctuating and could have a major impact on the costs. Cost TCX recommends continuing to monitor this risk and update fuel prices and impacts as the project moves forward.

Borrow/Placement Conflict with Multiple Contracts - The Cost TCX believes that this risk will be further understood after investigations of the material required for the backfill of the Miami Canal and the material available from the enlargement of the L-5 canal is better understood. It is also believed that a further developed acquisition plan could allow for a refinement of the estimate and this risk.

7.1.2 Schedule Risk

The key schedule risk driver identified through sensitivity analysis is the Project and Program MGMT Risk P-PPM-4 (Funding Profile), which contributes 92 percent of the statistical schedule variance and causing most of the schedule variation impacts.

P-PPM-4 Funding Profile - The base funding is on a constant $100M/year construction schedule for the assumed project schedule. Changing the annual level of funding amount could change the duration significantly from what is assumed. This could result in a change in the construction order and require a different work approach in some phases of the construction. The Cost TCX recommends management further refine the anticipated annual contributions from both USACE and the local sponsor.

Secondary schedule risk drivers are PED Start date (P-PPM-3) and Large Project Size will Require Multiple Contracts (P-CA-1).

PED Start date – The start of the project is highly dependent on the passing of legislation to specifically authorize the project as well as the success of the current accelerated planning process. Additional design, reviews, and or reformulation prior to the completion to the project Feasibility report could be required delaying the start of the project.

Large Project will Require Multiple Contracts – This is a large and complex project. Though considerable effort was expended to develop a logical sequence and breakout of the construction, there most likely will be some issues with coordination and overlap of multiple successive contracts. The Cost TCX recommends early involvement of contracting as well as close coordination of the Construction Division to ensure that each project can move forward in a timely manner with minimal impacts to the overall schedule.

Table 3. MCACES Estimate Cost Confidence Summary

Contingency Analysis

MCACES Estimate	$961,252,700*		
Confidence Level	Project Cost	Contingency	Contingency %
0%	$893,965,011	($67,287,689)	-7%
5%	$1,095,828,078	$134,575,378	14%
10%	$1,134,278,186	$173,025,486	18%
15%	$1,163,115,767	$201,863,067	21%
20%	$1,182,340,821	$221,088,121	23%
25%	$1,201,565,875	$240,313,175	25%
30%	$1,220,790,929	$259,538,229	27%
35%	$1,230,403,456	$269,150,756	28%
40%	$1,249,628,510	$288,375,810	30%
45%	$1,268,853,564	$307,600,864	32%
50%	$1,278,466,091	$317,213,391	33%
55%	$1,297,691,145	$336,438,445	35%
60%	$1,316,916,199	$355,663,499	37%
65%	$1,326,528,726	$365,276,026	38%
70%	$1,345,753,780	$384,501,080	40%
75%	$1,364,978,834	$403,726,134	42%
80%	$1,384,203,888	$422,951,188	44%
85%	$1,403,428,942	$442,176,242	46%
90%	$1,432,266,523	$471,013,823	49%
95%	$1,489,941,685	$528,688,985	55%
100%	$1,711,029,806	$749,777,106	78%

*Includes future real estate costs of approx $3M, but excludes 30/31 account costs.

Figure 3. Project Cost Summary Curve

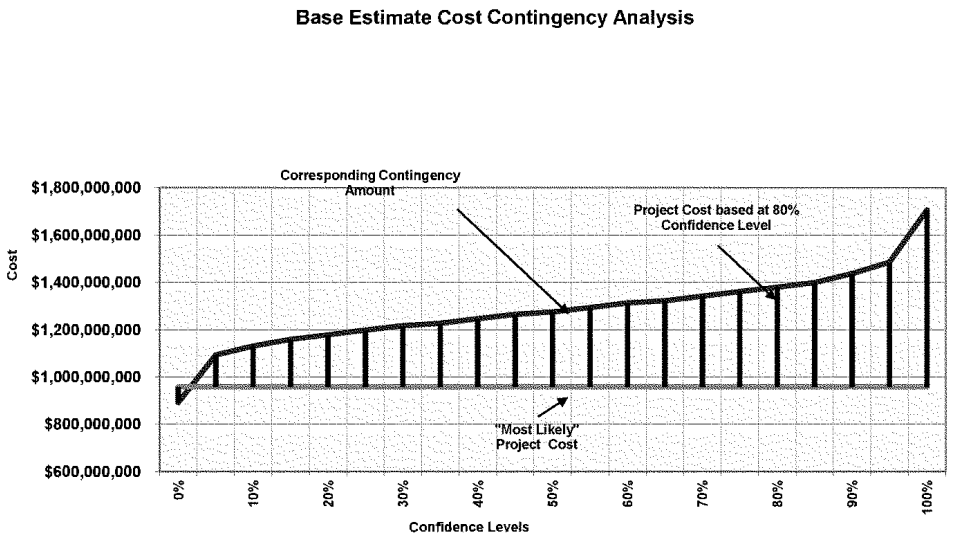


Figure 4. Project Duration Summary

Contingency Analysis

Most Likely Schedule Duration	329.0 Months		
Confidence Level	Project Duration	Contingency	Contingency %
0%	309.0 Months	-20 Months	-6%
5%	349.0 Months	20 Months	6%
10%	359.0 Months	30 Months	9%
15%	362.0 Months	33 Months	10%
20%	369.0 Months	40 Months	12%
25%	372.0 Months	43 Months	13%
30%	379.0 Months	50 Months	15%
35%	382.0 Months	53 Months	16%
40%	385.0 Months	56 Months	17%
45%	389.0 Months	60 Months	18%
50%	392.0 Months	63 Months	19%
55%	395.0 Months	66 Months	20%
60%	399.0 Months	70 Months	21%
65%	402.0 Months	73 Months	22%
70%	408.0 Months	79 Months	24%
75%	412.0 Months	83 Months	25%
80%	418.0 Months	89 Months	27%
85%	422.0 Months	93 Months	28%
90%	431.0 Months	102 Months	31%
95%	441.0 Months	112 Months	34%
100%	491.0 Months	162 Months	49%

* Base schedule based on $100M per year fixed funding

7.2 Recommendations

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 4th edition*, states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that the proactive management of risks not conclude with the study completed in this report.

Project leadership should review risk items identified in the original risk register and add others, as required, throughout the project life cycle. Risks should be reviewed for status and reevaluation (using qualitative measure, at a minimum) and placed on risk management watch lists if any risk's likelihood or impact significantly increases. Project leadership should also be mindful of the potential for secondary (new risks created specifically by the response to an original risk) and residual risks (risks that remain and must be managed).

Specifically for this project, the risks of changes to the project scope due to biological opinions, interdependency on the completion of other projects in the region, as well as the typical design evolution in the Preconstruction Engineering and Design Phase and Construction General Phase need to be carefully monitored and managed as the project progresses. Annual updating of project costs, schedule, and risk should be conducted in order to monitor changes that could adversely affect the project cost.

APPENDIX A

RISK REGISTER AND MODEL

Project Details

District:	SAJ
Project:	Central Everglades Planning Project (CEPP)
Study Phase:	Accelerated Smart Planning Process for feasability
Document Type:	Engineering Apendix From CEPP Draft PIR and EIS
Document Date:	March 2013 with updates through Dec 2013
Project Scope:	The study area for the Central Everglades Planning Project (CEPP) encompasses the Northern Estuaries (St. Lucie River and Indian River Lagoon and the Caloosahatchee River and Estuary), Lake Okeechobee, a portion of the EAA, the Water Conservation Areas (WCAs), Everglades National Park (ENP), the Southern Estuaries (Florida Bay and Biscayne Bay), and the Lower East Coast. The purpose of CEPP is to improve the quantity, quality, timing and distribution of water flows to the Central Everglades.
Risk Lead:	Nick Emigh/Mike Jacobs
Risk Report (A):	
(B):	
(C):	
(D):	
(E):	

Risk Matrix

Likelihood of Occurrence	Impact or Consequence of Occurrence				
	Negligible	Marginal	Significant	Critical	Crisis
Certain	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Very Likely	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Likely	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Unlikely	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Very Unlikely	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Likelihood of Occurrence Table

Any changes to these assumptions will change the assumptions in the models.

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Percent's above are based on 10 events, and are considered approximate, judgement should be used for final grouping dependant on # of occurances, project size, flexibility and complexity.

If event occurrence is...	then it's likelihood is thought to be between...
Certain	100%
Very Likely	70% and 90%
Likely	30% and 70%
Unlikely	6% and 30%
Very Unlikely	0% and 5%

Likelihood of Occurrence Tables.

If an event is

Certain: implies the event has a 100% chance of occurrence.

Very Likely: implies the event has a 70% to 90% chance of occurrence.

Likely: implies the event has a 30% to 70% chance of occurrence.

Unlikely: implies the event has a 6% to 30% chance of occurrence.

Very Unlikely: implies the event has a 0% to 5% chance of occurrence.

Impact or Consequence of Occurrence

Any changes to these assumptions will change the assumptions in the models.

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Percent's above are based on 10 events, and are considered approximate, judgement should be used for final grouping dependant on # of occurances, project size, flexibility and complexity.

If event occurrence is...	then it's impact to total project cost is thought to be between...
Negligible	0% and .5%
Marginal	.5% and 2%
Significant	2% and 3.%
Critical	3.% and 5%
Crisis	over 5%

Impact or Consequence of Occurrence

If an event is classified as....

Negligible: implies the event has a 0% to .5% chance of occurrence.

Marginal: implies the event has a .5% to 2% chance of occurrence.

Significant: implies the event has a 2.% to 3% chance of occurrence.

Critical: implies the event has a 3.% to 5% chance of occurrence.

Crisis: implies the event has a greater than 5% to % chance of occurrence.

SAJ - Jacksonville

SAJ - CEPP Cost and Schedule Risk Analysis

Initial Risk Register Development Meeting

Date 2/4/2013 to 2/8/2013

No.	Name	Section
1	Kim Vitek	PM-EO
2	Murika Davis	PD-C
3	Andrew Loschilavo	PD-E
4	Bill Hamel	CD-Q
5	Kelly Keefe	PD-C
6	Dan Crawford	EN-WM
7	Kevin Wittmann	PD-C
8	Amanda Lavigne	EN-WM
9	Jack Fross	EN-DS
10	Manuel Dejesus	EN-DM
11	Donna George	PM-EE
11	Brad Foster	PD-C
12	Kim Brooks Hall	EN-T
12	Tracy Leeser	EN-TC
13	Gwen Nelson	EW-DL
13	Cindy Thomas	PD-C
14	Jonathan Jenkins	OD-MW
14	Jimmy Matthews	EN-Q
15	Nick Emigh	NWW EC-X
15	Mike Jacobs	NWW EC-X
16	Joseph Tavares	CD-Q
16	Scott Thorught	SFWMD
17	Al Shirket	SFWMD
17	Paul Linton	SFWMD
18	Agnes McClean	ENP
18	Kevin Koton	ENP
19	Bob Johnson	ENP
19	Dennis Duke	DOI
20	Inger Hansen	FDEP
20	Miles Myers	FWS
21	Liberta Scotto	FWS
21	Amro Habib	EN-TC
22	Frank Vicidomina	MVN-PM
22	Rob Tucker	EN-H

Project Cost (Less Contingencies and Escalation)

** Construction costs & real estate costs taken from MII.*

*** See "E&D" Excel sheet for E&D/S&A assumptions.*

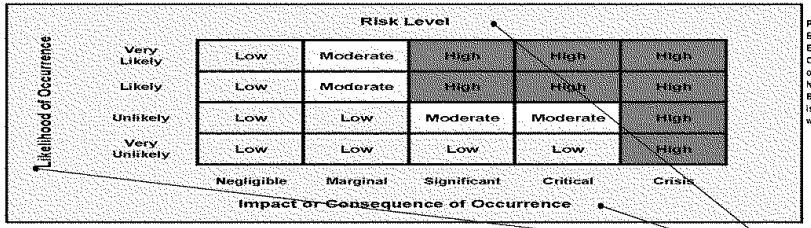
ACCT	DESCRIPTION		COST ($)	
Construction Costs*				
00	Flood proofing Allowance			
01	Lands & Damages		2,987,000	FROM SAJ(remaining costs only
02	Relocations			
03	Reservoirs			
04	Dams			
05	Locks			
06	Fish & Wildlife Facilities		72,516,000	FROM SAJ
07	Power Plant			
08	Roads, Railroads, & Bridges			
09	Channels & Canals		252,727,187	FROM MCACES
10	Breakwaters & Seawalls			
11	Levees & Floodwalls		273,503,603	FROM MCACES
12	Navigation Ports & Harbors			
13	Pumping Plants		91,807,997	FROM MCACES
14	Recreation Facilities		4,440,568	FROM MCACES
15	Floodway Control & Diversion Structures		234,171,345	FROM MCACES
16	Bank Stabilization			
17	Beach Replenishment			
18	Cultural Resource Preservation		18,065,000	FROM SAJ
19	Buildings, Grounds, & Utilities			
20	Permanent Operating Equipment			
			856,650,700	MCACES VALUE
	Summary Construction Costs and L&D		**950,218,700**	Excludes spent real estate

Non-construction Costs			
30	Planning, Engineering & Design**	27.5%	235,578,943
	Project Management	*3.00%*	*25,699,521*
	Planning & Environmental Compliance	*2.50%*	*21,416,268*
	Engineering & Design	*11.50%*	*98,514,831*
	Engineering Tech Review ITR & VE	*2.00%*	*17,133,014*
	Contracting & Reprographics	*2.50%*	*21,416,268*
	Engineering During Construction	*3.50%*	*29,982,775*
	Planning During Construction	*2.50%*	*21,416,268*
	Port S&A		-
31	Supervision & Administration**	10.5%	89,948,324
	Supervision & Assurance:	8.0%	*68,532,056*
	Project Operation:	1.0%	*8,566,507*
	Program Management:	1.5%	*12,849,761*

Summary 30 & 31 Account		**325,527,266**
32	HTRW	625,000
Summary 32 Account		**625,000**

ROM First Cost (without cont)		**1,276,371,000**
	from	to
	Oct-2019	Oct-2046
Schedule Length (without Contingency)		**329** Months
Schedule Length		329 Months

SAJ - CEPP Cost and Schedule Risk Analysis



Project Scope Narrative: The study area for the Central Everglades Planning Project (CEPP) encompasses the Northern Estuaries (St. Lucie River and Indian River Lagoon and the Caloosahatchee River and Estuary), Lake Okeechobee, a portion of the EAA, the Water Conservation Areas (WCAs), Everglades National Park (ENP), the Southern Estuaries (Florida Bay and Biscayne Bay), and the Lower East Coast. The purpose of CEPP is to improve the quantity, quality, timing and distribution of water flows to the Central Everglades.

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions & Conclusions	Project Cost			Project Schedule			Affected Project Component
				Likelihood*	Impact*	Risk Level*	Likelihood*	Impact*	Risk Level*	
Contract Risks (Normal Risk Items are things that are generated, caused, or controlled within the PDT's sphere of influence.)										
PROJECT & PROGRAM RISKS										
P-PPM-1	New Planning Process Review Revisions	As the project reaches mile stones and HQ revises or asks for changes to the process	The concern is during the 2x3x3 planning phase HQ revises the anticipated out come of the planning study and delays in the authorization schedule will be encountered.	Very Likely	Negligible	LOW	Likely	Marginal	MODERATE	Project Cost & Schedule
P-PPM-2	Multiple overlapping projects	There are multiple overlapping projects and accounting for costs and benefits may be overlapping. Overall system needs to work together to provide benefits.	There are numerous projects within the area that may have different purposes and overlapping features. This may cause accounting and authorization issues due to cost share and project purposes.	Very Likely	Significant		Very Likely	Significant		Project Cost & Schedule
P-PPM-3	PED Start date	PED phase will most likely not start until next WRDA is passed.	FY 2016 is probably the earliest authorization would occur. However this could change depending on the next WRDA's actual progress.	Very Likely	Negligible	LOW	Very Likely	Critical		Project Cost & Schedule
P-PPM-4	Funding Profile	Project implimation is dependent on both the federal and sponsor living able to meet federal obligation to meet the project.	Equal contributions or cost share from the sponsor and from USACE will be needed for future work. Progress could vary based on actual fiscal contributions in funding the project.	Likely	Marginal	MODERATE	Likely	Significant		Project Cost & Schedule
NR-PPM-5	Integrated FEB Operations A1 and A2	It is assumed that A1 will be completed prior to construction of A2 (Start FEB 2018 Completed 2018)	Some minor changes in design or assumed operating conditions may result depending on final configuration of A2. This is an opportunity for savings	Likely	Marginal	MODERATE	Likely	Negligible	LOW	Project Cost & Schedule
PPM-8	Local Escalation Greater than National Average	When dealing with large multiple year projects there are concerns for localized inflation above CWCCIS.	The concern is that due to funding restrictions and multiple contracts that inflation in CWCCIS will be outpaced in future years. This is the possibility that inflation exceeds the CWCCIS tables in future years.	Unlikely	Crisis		Likely	Negligible	LOW	Project Cost & Schedule
CONTRACT ACQUISITION RISKS										
P-CA-1	Large project siz/multiple projects	Most likely due to the large size of the project the project will be broken up into small individual contracts	Coordination and sequencing may change significantly due to acquisition approach. Some thought has been put into contract acquisition into base case estimate however schedule and cost could change based on actual implementation	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE	Project Cost & Schedule
SR-CA-2	Borrow/Placement Conflict with Multiple Contracts	Concern for scoping of projects to ensure that the backfill and excavation and structure modifications are in the same contract	L8 - L9 must be completed together along with modifications to S-8 and Intake belt fill are all required to be completed in series. This could affect construction cost and schedule.	Very Likely	Significant		Very Likely	Marginal	MODERATE	Project Cost & Schedule
TECHNICAL RISKS										
P-TL-1	Life Cycle Cost Analysis on Pump stations	Life cycle cost analysis during design may show that additional pumping is more beneficial.	This could lead to increased unit cost for pump station costs due to infrastructure requirements.	Unlikely	Marginal	LOW	Very Unlikely	Negligible	LOW	Project Cost & Schedule
NR-TL-3	FEB Internal Water Conveyance	There are existing A/S canals in the proposed location of the FEB along with roads bordering each side of the canal that may cause issues	There is the possibility of piping through the proposed location of the perimeter levee. There is also the concern for not allowing sheet flow across the FEB with out backfilling or plugging the A/S canals	Very Likely	Marginal	MODERATE	Very Likely	Marginal	MODERATE	Project Cost & Schedule

NR-TL-4	FEB North Spreader Canal Length	Currently the spreader canal is only on part of the northern end of the FEB.	There is concern that the canal may need to extend along the entire northern end including routing the spreader canal south and west to humate the east end of the FEB. This will lengthen the canal and additional costs and based on limited funding stream will add additional time to the schedule.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE	Project Cost & Schedule
NR-TL-5	FEB Porosity of Lime Rock is Unknown	There is the concern that the lime rock is not capable of containing the water.	Unknown geotechnical data. There is concern that there could be a need to for additional work under the FEB perimeter levee. A1 will be constructed prior to A2 and may provide some freeboard of issues.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE	Project Cost & Schedule
SR-TL-6	S-8 Flood Control Operations	S-8 needs to provide flood control the entire time until downstream work is complete	A plan and appropriate tools have been incorporated in the features effected by the operation of the S-8 pump station. This includes the gated culverts down stream of the pump station including de-snag in canals. If any additional work is needed to ensure flood protection it will cause additional cost and could lengthen the schedule.	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE	Project Cost & Schedule
SR-TL-7	S-8 New Pump Station Design	The current plan is unclear on the status of S-8 Pump Station. This could require actions ranging from full replacement to minor modifications.	The Engineering Appendix does not provided sufficient information to determine what the new design of the S-8 pump station. It is likely that the pump station will need additional work to ensure that the pumps are capable of handling the flood waters. This could range from a new pump station to a rehab of the existing pump station.	Likely	Cross	[redacted]	Likely	Negligible	LOW	Project Cost & Schedule
SR-TL-8	Adverse effects to WCA2	Overall system operation must not impact WCA-2	The understanding at this time is that there should be no affect to the WCA2 with the operation of the entire system. This could result in delays to NEPA and permitting based on reviews of the overall system.	Likely	Negligible	LOW	Likely	Negligible	LOW	Project Cost & Schedule
SR-TL-9	G-335G Capability to Increase	Usability of existing structure is in question.	There is the possibility that the structure has more capability and will need little to no work. However if additional work is required there would be a need for additional costs.	Likely	Marginal	MODERATE	Likely	Negligible	LOW	Project Cost & Schedule
SR-TL-12	L-4 Pipeline	A known abandoned pipe line exists in the area of the L-4 Degrade.	Currently it is unknown if the previous cleanup was sufficient to ensure that there are contaminated soils or debris from the pipeline. The current state and location of the pipeline is unknown at this time.	Very Likely	Negligible	LOW	Very Likely	Negligible	LOW	Project Cost & Schedule
SR-TL-13	Miami Canal Pipeline	There is an abandoned pipeline in the vicinity of Miami Canal	Locations is known and addressed. Low Low	Very Likely	Negligible	LOW	Very Likely	Negligible	LOW	
BG-TL-15	Tamiami Trail Bridges and Roads Raise	This work needs to be completed prior to CEPP and needs to be completed for project to operate as designed	Current scheduled completion dates for these features need to be considered in the implementation schedule for this project. If they are not completed they most likely would delay the CEPP project completion.	Very Unlikely	Negligible	LOW	Unlikely	Cross	[redacted]	Project Cost & Schedule
BG-TL-19	Eastern Flight 401	The new proposed Monument is at the current location of 592 monument	If this new monument is built in a different location than anticipated there could be additional impacts to design. There may be momentum to place new Valiar Jet memorial	Unlikely	Marginal	LOW	Unlikely	Marginal	LOW	Project Cost & Schedule
BG-TL-20	De-Comp Physical Model Results	There is the possibility that the de-comp model will change the design of some or all features	L-67C could need to be backfilled or plugged as a result of the de-comp model results. There is also the possibility of features changing based on the results of the De-Comp study. This may be difficult or impossible to model. Current needs is based on best known information. This should be included on the watch list of risks.	Unlikely	Significant	MODERATE	Unlikely	Significant	MODERATE	Project Cost & Schedule
BG-TL-21	Collector Canal at S-356B	There is concern that there could be the need for a collector canal at the location of the current S-356B	This is not included in the current construction estimate or scope. It will allow for the water to be drained out of the WCA 3B. The cost for a collector canal at S-356B is included in the adaptive management cost estimate. This is not modeled in the risk as this cost is in the adaptive management base costs.	Likely	Marginal	MODERATE	Unlikely	Marginal	LOW	Project Cost & Schedule
Y-TL-22	S-356 Pump Operation	There is currently no water quality permit to operate the existing pumps. There is concern that the same water quality issues may impede design of new pump station.	There are a myriad of issues that could change short/long term usage of the current pump station. Some thought is that it could be used in the short term to validate the size of the final permanent pump station. It is unclear how this outcome could affect the project at this time.	Likely	Negligible	LOW	Very Unlikely	Negligible	LOW	Project Cost & Schedule
Y-TL-24	S-356 Sizing of New Pump	The new pump is currently assumed at 1000 CFS.	There is an uncertainty that the pump size is correct for the anticipated seepage. This may require monitoring and flexibility of sizing of pump station.	Likely	Negligible	LOW	Likely	Negligible	LOW	Project Cost & Schedule
Y-TL-25	Pumping into Canal	There is flexibility to allow for pumping into the canal through S-357 to provide water to the L31 canal	There is a benefit in the ability to be able to control the water out of WCA3 into the canal to allow a supply of water to Miami. It is unknown if there is a direct relationship between water in the canal and water being sent to the aquifer.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW	Project Cost & Schedule

Y-TL-28	S-356 New Pump Station Design	It is unknown about the bug room this poses a life design	Noise, design of structure, and vibrations generated from pumps and could lead lands have been on hold in the past. There is concern for the proximity to the pumps, owned by the [illegible] and the noise and vibrations that may be generated by pumps, or require additional aesthetics or sound proofing features	Very Likely	Negligible	MODERATE	Very Unlikely	Negligible	LOW		Project Cost & Schedule
BG-TL-27	Blue Shanty Levee Foundation	There is little to no data in the area of this levee.	The need for upgrades to the foundation design may be needed. This could ensure that there was enough piping under the levee. The future design could include the use of filter cloth to increase the stability of the levee foundation	Likely	Marginal	MODERATE	Likely	Negligible	LOW		Project Cost & Schedule
TL-28	Global Geo Tech Assemblons	There been varied assumptions for the material yields for some project although most geotechnical those that these can vary significantly throughout the region.	Any notable variance in the material type could have an impact on the cost of excavation	Likely	Significant	MODERATE	Likely	Negligible	LOW		Project Cost & Schedule
TL-29	Disposal of Excess on Site Material	Currently there is no design for location or thickness of waste disposal of excess material	There is likely one chance that additional work will be required to carefully dispose of the material on site. This could result from spreading across areas that were not originally planned for.	Very Likely	Significant	MODERATE	Very Likely	Negligible	LOW		Project Cost & Schedule
TL-30	Levee Stabilization Approach	Currently the stabilized has yielded on the means of stabilization for the levee slope of the levees	Previously exists that needed more rip rap should be placed to ensure the stabilization of the levee. Without rock this areas might need to be covered as well	Unlikely	Critical	MODERATE	Unlikely	Negligible	LOW		Project Cost & Schedule
TL-31	System not performing as intended	There is a concern a risk that the system may not perform as designed and that the system may not meet the needs	Some minor relocations, inputs of changes may be required due to unforseen issues. This will need to be monitored to ensure the system performs as intended and adjustments are made to ensure the system is met	Likely	Critical	MODERATE	Unlikely	Negligible	LOW		Project Cost & Schedule
	LANDS AND DAMAGES RISKS										
NR-LD-1	FEB H7RW	There is the possibility that the Farm Lands may have H7RW in the area	There is likely one or areas that will have additional work to ensure that the lands free of these that may require additional stabilization of the FEB	Very Likely	Marginal	MODERATE	Very Likely	Negligible	LOW		Project Cost & Schedule
NR-LD-2	Miami Canal Historical status	There is a portion of the Miami Canal that is considered historical	It is listed as a historical historical location and is known that portions of the canal have been filled in. Additional coordination will be needed and documented	Likely	Negligible	LOW	Likely	Negligible	LOW		Project Cost & Schedule
NR-LD-3	FEB Land ownership	The land is currently owned by the state and leased by AAA Lake	There is minimal risk that the land will be an issue, it is state owned and leased by AAA Lake. The land is currently owned and should be considered a positive detail	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW		Project Cost & Schedule
NR-LD-4	FEB lands Coordination in Termination of Leases for FEB	The risk is that there will be a delay between the lease being opposed and the start of construction	There is concern that some spaces will establish in the site after the lease is abandoned by the farmer and the start of construction. There could be an impact if they are protected species that have moved into the area. There is a concern that is felt that the affected landowners will allow for proper timing of termination of leases and to allow time to transition	Very Unlikely	Significant	LOW	Unlikely	Negligible	LOW		Project Cost & Schedule
SR-LD-5	Effects West of L-28 and North of I-75	Concern from tenants that the cattle pasture is well fed throughout the system	There is concern that some species will establish in the site after the lease is abandoned by the farmer and the start of construction. There could be an impact if they are protected species that have moved into the area. There is a concern that is felt that the affected landowners will allow for proper timing of termination of leases and to allow time to transition	Unlikely	Negligible	LOW	Unlikely	Negligible	LOW		Project Cost & Schedule
SR-LD-6	Hunting Camps	Hunting Camps within the area between the Miami Canal and the L-6 Levee	This concern is that there might be access issues from the levee to the camp. There may also be potential changes to the access road along the Miami Canal	Negligible	Negligible	LOW	Very Unlikely	Negligible	LOW		Project Cost & Schedule
BG-LD-8	Mitigation of Lands	The concern is that mitigation necessary to complete the project will be acquired by other projects along Tamiami Trail	There is a risk that some lands proposed to be acquired by other projects may not be acquired due to existing. This could delay the project	Unlikely	Marginal	LOW	Unlikely	Significant	MODERATE		Project Cost & Schedule
BG-LD-9	Tribal Community Structures Elevation	There is concern that the two tribal communities along the Tamiami trail may have structures that need to be raised	Many of the structures have been constructed at higher anticipated water elevations. Although some of the structures may not have design to accelerate with the project. A cost analysis may be used for cost per schedule	Unlikely	Marginal	LOW	Unlikely	Marginal	LOW		Project Cost & Schedule
Y-LD-10	Lands for New Pump S356	The current location of the new pump is in the perceived property of the Miccosukee tribal lands	There is likely one or more areas that will require additional work to ensure that the lands free of these that may require additional stabilization of the FEB	Likely	Negligible	MODERATE	Likely	Negligible	LOW		Project Cost & Schedule
Y-LD-11	Cutoff Wall Location	The proposed location of the cutoff wall is along the alignment of the existing levee and within the existing right of way	Not anticipated to be many areas with access or easement to be good.	Very Unlikely	Negligible	LOW	Very Unlikely	Negligible	LOW		Project Cost & Schedule

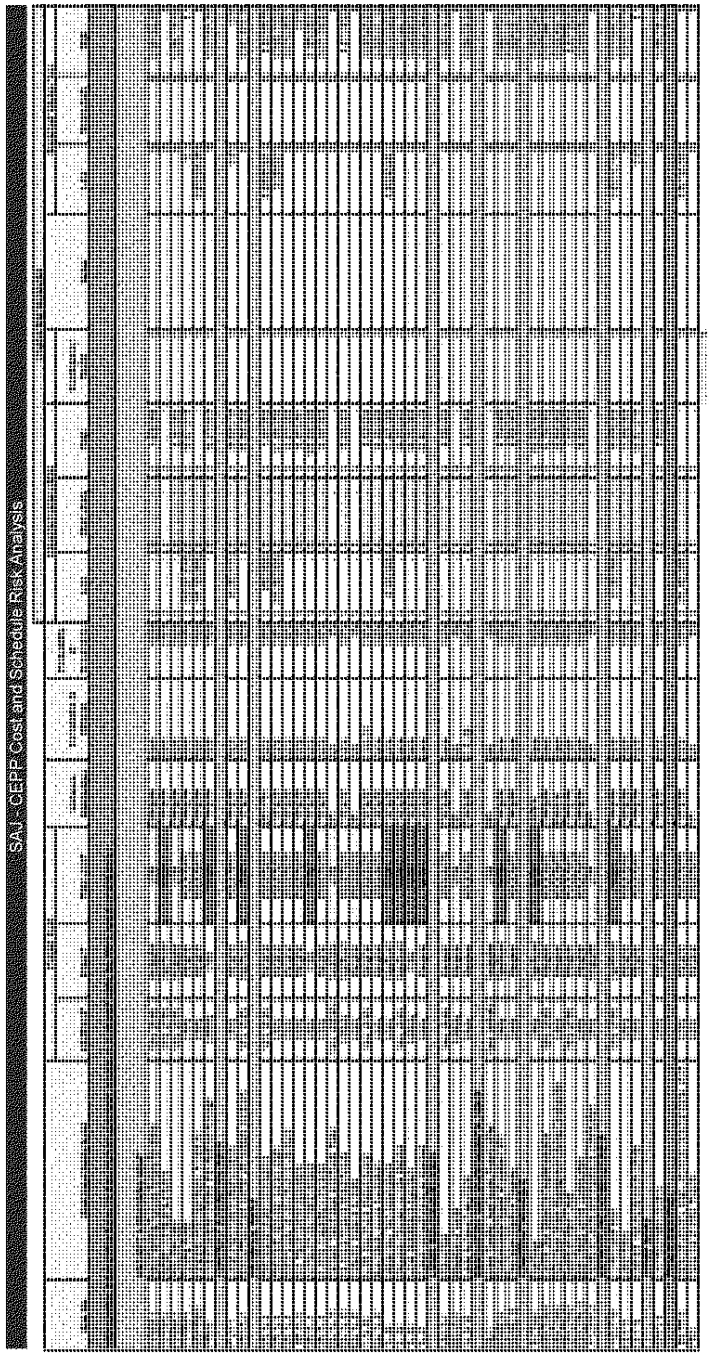
SR-LD-12	Miami Canal Existing Recreation	The current recreation features along the western of the Miami canal are considered to be a valued community asset	There are multiple recreation locations and features adjacent to the Miami canal that could be impacted by the construction activities. Features such as the bridge just south of the C-191 canal regard construction. There are creek to maintain some recreational activities access intact	Likely	Negligible	LOW	Likely	Negligible	LOW			Project Cost & Schedule
	REGULATORY AND ENVIRONMENTAL risks													
P-RE-1	Endangered Species on Levees and Excavation sites	Endangered species known to be manatee, crocodile, ibises, etc.	Some endangered species (above) should be considered in construction activities to include nesting season, work windows, and monitoring plans. This has been taken into account in the cost estimate	Very Likely	Negligible	LOW	Likely	Negligible	LOW			Project Cost & Schedule
RE-2	Water Quality Legal Issues Project Wide	Water quality on system has been challenged before.	It is assumed that this will be resolved and water quality will be acceptable prior to the construction of CEPP. Legal action or delays could significantly delay the project if this is not resolved. Water quality issues will be resolved and accepted prior to construction of the project.	Very Unlikely	Negligible	LOW	Unlikely	Crisis	HIGH			Project Cost & Schedule
NR-RE-3	FEB Cultural Resources	Due to the nature of the area historical artifacts may be found during excavation	During excavation there is the possibility of encountering cultural resources. Any findings will be addressed per the current scope of the mitigation agreements and may decrease the likelihood in this area. Although cultural resources making up lower levels in the overall probability	Very Likely	Negligible	LOW	Very Likely	Negligible	LOW			Project Cost & Schedule
SR-RE-4	S-9 National Registry	They S-9 structure is eligible or potentially eligible for national register as a historical structure.	This entire area is considered as eligible for the national register. There are no changes will need to be documented during construction. This will be considered accepted	Likely	Negligible	LOW	Likely	Negligible	LOW			Project Cost & Schedule
SR-RE-5	L-4 Archaeological Site	There is an area south of the L-4 Levee and West of the Miami canal that is eligible or potentially eligible for national registry as an archeological site.	A cluster of native trees from the area identified at the intersection of L-4 to the Miami Canal could impact an archeological site. The reservation need protection and documentation during construction activities	Likely	Negligible	LOW	Likely	Negligible	LOW			Project Cost & Schedule
SR-RE-6	L-6 Shoutouts	The Structures along the L-2 are eligible or potentially eligible for national registry as a historical structure	It is unknown at this time if they are considered historical. However, it is likely they are not based on the documentation to ensure that these are not mistaken out the appropriate documentation	Likely	Negligible	LOW	Likely	Negligible	LOW			Project Cost & Schedule
SR-RE-8	Manatees	In 2005 the Miami Canal at this area to make channelsbeds was listed as possibly having manatees in the canals	Blocking of canals was done to ensure that the manatees were not in the area during construction. Permits have been awarded to remove the area from listing. There may be documentation that the Miami canal has been removed from this legislation list	Very Likely	Negligible	LOW	Very Likely	Negligible	LOW			Project Cost & Schedule
BG-RE-9	Environmental Impact of system L67C	NEPA impacts of enlarging the effected area needs to be considered. It is unclear if the areas and wetlands will ensure a net positive effect	It is unclear if the level of impact to this outside will be ideal after construction. The entire downstream effected by removing the L67C and backfilling the Canal is complex because as the results could change the plan	Likely	Significant	LOW	Likely	Marginal	MODERATE			Project Cost & Schedule
BG-RE-10	L67-A Tree Islands	Some of the land owners participant at L-67A currently have certain grandfathered members	3 x boundary stakeholder buyer approval of conditions should be needed as it is that the team can ensure that the stands do be removed do not have camps	Likely	Negligible	LOW	Likely	Negligible	LOW			Project Cost & Schedule
BG-RE-11	Tree Islands in Blue Shanty Flow way	Currently there are islands in the area that should not be disturbed	There is concern that the Blue Shanty levee will be located on the tree islands. Any impacts will require additional measures to be in place to ensure that the islands are not disturbed during construction. This has added a very intensive presence for team critical and biologists	Likely	Negligible	LOW	Likely	Negligible	LOW			Project Cost & Schedule
BG-RE-12	Blue Shanty Levee Location	There is concern that the new Blue Shanty levee will be located on the tree islands. Any impacts will require additional measures to be in place to ensure that the islands are not disturbed during construction. This has added a very intensive presence for team critical and biologists	The will need to be addressed in design and planned to be located outside of the tree islands. Any impacts will require additional measures to be in place to ensure that the islands are not disturbed during construction. This has added a very intensive presence for team critical and biologists	Likely	Negligible	LOW	Likely	Negligible	LOW			Project Cost & Schedule
BG-RE-13	Tree Island North of Chipola	There are historically significant tree islands south of Chipola Lakes	Trance islands cannot be effected in the construction or operation of the project. There is a potentially sensitive cultural site just south of the Chipola Lakes	Likely	Marginal	MODERATE	Likely	Negligible	LOW			Project Cost & Schedule
BG-RE-14	Old Tamiami Trail Removal	The City Tract is eligible or potentially eligible for national registry as a historical site	The entire area is considered as eligible for the national register. There are changes will need to be documented during construction. This will be considered accepted	Likely	Negligible	LOW	Likely	Negligible	LOW			Project Cost & Schedule
Y-RE-15	Miners cutoff wall	The miners are contributing a campaign cutoff wall for multiple flow moving effects	Early results suggest that the 2 miles cutoff as the miners are contributing will not be considered to this portion of the project	Likely	Negligible	LOW	Likely	Negligible	LOW			Project Cost & Schedule

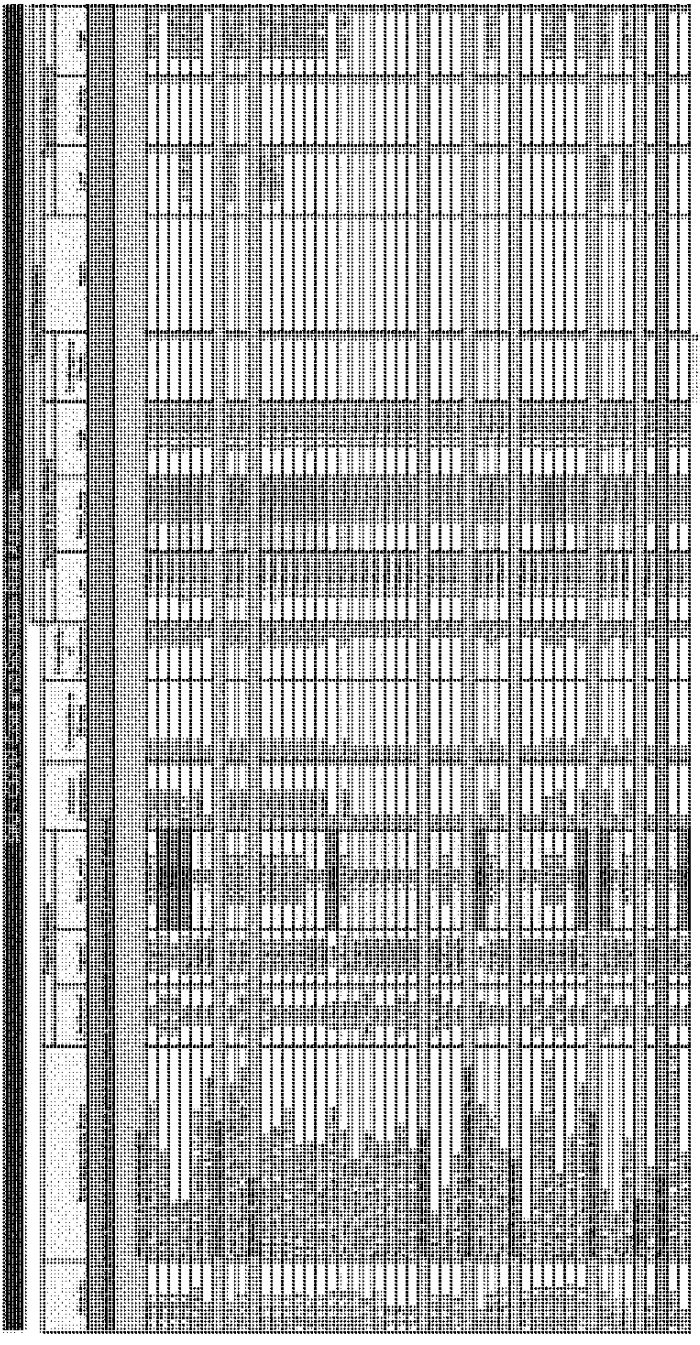
P-RE-16	Costs for cultural resources	Cultural Resources presentation	Ensure adequate costs for cultural resource investigation and mitigation included	Very Unlikely	Negligible	Low	Very Unlikely	Negligible	Low	Project Cost & Schedule
	CONSTRUCTION RISKS									
P-CON-1	Fuel Price	Due to the large quantity of energy that will take place on this job there is a chance that fuel prices increasing could impact the job	It is unknown at this time what the future of fuel prices will do. This cost has the potential to significantly impact the project if how fuel prices will affect this job	Likely	Significant	MODERATE	Likely	Negligible	LOW	Project Cost & Schedule
NR-CON-4	Cut Fill Qtys Based on Implementation	CH2M's backfilled model away from estimate	The concern is that you will have cut less material than the estimate and have to import more material. This could also change borrow pit requirements	Very Likely	Marginal	MODERATE	Very Likely	Negligible	LOW	Project Cost & Schedule
NR-CON-5	Access Roads used for FEB Construction	A1 FEB is assumed available for access to A2 construction.	It is assumed that A1 will be built prior to the construction of A2. Considerations for haul roads need to be accounted for on the estimate. The estimate assumes improving haul roads after usage as noticed for this was not provided providing the FEB	Unlikely	Negligible	MODERATE	Very Likely	Negligible	LOW	Project Cost & Schedule
NR-CON-6	FEB Storm Water Management during Construction	The concern is that there will be water intrude in the area during a storm	There is the possibility that the water will need to be pumped at allowed to dry. There is concern that during the process of scheduling the work there will be delays that adversely impact the expected construction schedule	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE	Project Cost & Schedule
SR-CON-8	Maintenance of Vegetation on L4_AREA_3A	There is concern for conveyance along the L-4 Canal and the impact that vegetation would have in the short term on flows into Holeyton Conservation Area 3A.	There is a need to ensure that during the construction phase the removal of vegetation that will ensure the hydraulically effective capacity is maintained	Likely	Negligible	LOW	Likely	Negligible	LOW	Project Cost & Schedule
SR-CON-9	Backfill of Miami Canal	There is concern for sequence of construction and backfilling the Miami Canal	There is concern that the sequence will impact construction and put impacted the amount of excavation, dewatering and backfill. Not currently in the estimate. Pumping and project schedule could impact this considerably	Very Likely	Negligible	MODERATE	Very Likely	Marginal	MODERATE	Project Cost & Schedule
BG-CON-11	Blue Shanty Levee Construction	Scheduling could cause borrow pit issues	Flood protection will be required during construction. It is not likely that it will be required to be in operation for the Blue Shanty Borrow Pit	Likely	Marginal	MODERATE	Likely	Negligible	LOW	Project Cost & Schedule
Y-CON-12	Visibility of Casino and Impacts of Construction	Nearby Casino may be sensitive to noise and vibrations from construction.	The construction contractor may be impacted due to concern of vibrations from the Casino nearby. They could require restrictive construction activities placed on the contractor	Likely	Negligible	LOW	Likely	Significant	MODERATE	Project Cost & Schedule
CON-13	Pre Construction Survey of Canals	Currently it is unknown what this study will look like	It is known from work in the past many canals that a significant amount of muck is present in some or all of the canals. It is likely that a preconstruction survey will need to be completed prior to construction to ensure the capacities are known	Likely	Negligible	LOW	Likely	Negligible	LOW	Project Cost & Schedule
	ESTIMATE AND SCHEDULE RISKS									
BG-EST-6	L-29 Levee Removal	The length of levee that will need to be removed can vary based on the final length of the Blue Shanty Levee	This additional cost will need to be added to the estimate if the length changes	Very Likely	Negligible	LOW	Very Likely	Negligible	LOW	Project Cost & Schedule
BG-EST-7	L-67C Removal	The length of levee that will need to be removed depending on the location of the blue shanty levee will change	This additional cost will need to be added to the estimate if the length changes	Very Likely	Negligible	LOW	Very Likely	Negligible	LOW	Project Cost & Schedule
Y-EST-10	L-31N Cutoff Wall	There is concern to believe that information gathered from the recent cutoff wall will change the assumed height of the cutoff wall	Currently the cutoff is designed to a 35 ft depth based on the bench between the levee and the canal. This location may change based on the information gathered from the recent cutoff wall. Pin moving that additional depth or length may be required to achieve the proper effects. Currently could be as little as 2 percent of the cutoff wall that is constructed. Assuming 2-3 miles of this levee depth could	Very Likely	Significant	MODERATE	Very Likely	Significant	HIGH	Project Cost & Schedule
EST-11	Labor Rates	Local wage rate assumptions could vary from assumed and impact the estimate	Currently wage rates are low in the area however skilled workers generally are compensated higher wages only as projects require specialized labor. Impacts to the project can be significant	Likely	Marginal	MODERATE	Likely	Negligible	LOW	Project Cost & Schedule
EST-12	Estimate Assumptions/Like Similar	That features were estimated using plans from similar structures with minimal design for the CSSP feature The assumption that the features will be similar to the CSSP features that are currently proposed in the feature	The project has considered many site design and planning assumptions that will need to be verified as the project moves forward. Each feature can have significant impacts to the overall project cost and schedule if the similar feature assumptions in the estimate are not similar Additionally the estimate has to make significant assumptions in the acquisition to construction	Likely	Marginal	MODERATE	Likely	Marginal	MODERATE	Project Cost & Schedule

EST-13	Delays in Fabrication of Equipment	Due to the number of specialty fabricated gates, pumps and motors there could be an impact to the project	When dealing with specialty materials (gates pumps etc.) there is always concern that the raw materials may not be available. The risk is either that a premium will have to be paid for the material or equipment or a delay to the delivery schedule of the material or equipment will cause a delay to the project	Unlikely	Negligible	LOW	Unlikely	Marginal	LOW	Project Cost & Schedule
	OTHER RISKS									
NR-FL-1	FEB Recreation Features	Recreation features may be added to in the area of the FEB	Some recreation features are included. It is anticipated that the features will not be a major driver there is already a cost consideration for minimal recreation features in the estimate	Likely	Negligible	LOW	Likely	Negligible	LOW	Project Cost & Schedule
BG-FL-2	L-67 Recreation Access	Access for existing recreation features may need to be changed due to project construction	Some costs for relocating the recreation access to the L-67C and L-67A are included in the cost estimate. There is the risk that additional recreation sites may be needed and that improvements to existing levees to allow for vehicle access may be needed	Likely	Marginal	MODERATE	Likely	Negligible	LOW	Project Cost & Schedule
	Programmatic Risks	(External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)								
BG-PR-5	Gated Structures, Gaps, and levee removal along L67A	There is the possibility that the three gated structures in L67A, levee removal and gaps in L67C and L67 extension removal are included in another authorized project	Costs for 3 gated structures, the gaps along L67C and the Levee removal of the L67 extension are included in the costs of this project. If it is determined that they should not be included, their cost will be considered an opportunity	Likely	Marginal	MODERATE	Likely	Negligible	LOW	Project Cost & Schedule
PR-6	Close Out of Other Projects	HQ has not provided final confirmation that Mod-Waters will be closed out	Prioritization and closeout of other projects could affect the start and funding for this project. These affects could substantially change the project formulation and execution schedule. This risk will be mitigated not modeled	Likely	Marginal	MODERATE	Likely	Significant		Project Cost & Schedule
PR-7	Political or Public Opposition to project	There are many different agencies, organizations, and stakeholders in the project vicinity that could oppose portions of the project or its impacts real or perceived	Litigation, delays or fundamental project changes could result. This risk will be mitigated not modeled	Likely	Marginal	MODERATE	Likely	Significant		Project Cost & Schedule

*Likelihood, Impact, and Risk Level to be verified through market research and analysis (conducted by cost engineer).

1. Risk/Opportunity identified with reference to the Risk Identification Checklist and through deliberation and study of the PDT.
2. Discussions and Concerns elaborates on Risk/Opportunity Events and includes any assumptions or findings (should contain information pertinent to eventual study and analysis of event's impact to project).
3. Likelihood is a measure of the probability of the event occurring -- **Very Unlikely**, **Unlikely**, **Moderately Likely**, **Likely**, **Very Likely.** The likelihood of the event will be the same for both Cost and Schedule, regardless of impact.
4. Impact is a measure of the event's effect on project objectives with relation to scope, cost, and/or schedule – **Negligible**, **Marginal**, **Significant**, **Critical**, or **Crisis.** Impacts on Project Cost may vary in severity from impacts on Project Schedule.
5. Risk Level is the resultant of Likelihood and Impact **Low**, **Moderate**, or **High**. Refer to the matrix located at top of page.
6. Variance Distribution refers to the behavior of the individual risk item with respect to its potential effects on Project Cost and Schedule. For example, an item with clearly defined parameters and a solid most likely scenario would probably follow a triangular or normal distribution. A risk item for which the PDT has little data or probability of modeling with respect to effects on cost or schedule (i.e. "anyone's guess") would probably follow a uniform or discrete uniform distribution.
7. The responsibility or POC is the entity responsible as the Subject Matter Expert (SME) for action, monitoring, or information on the PDT for the identified risk or opportunity.
8. Correlation recognizes those risk events that may be related to one another. Care should be given to ensure the risks are handled correctly without a "double counting."
9. Affected Project Component identifies the specific item of the project to which the risk directly or strongly correlates.
10. Project Implications identifies whether or not the risk item affects project cost, project schedule, or both. The PDT is responsible for conducting studies for both Project Cost and for Project Schedule.
11. Results of the risk identification process are studied and further developed by the Cost Engineer, then analyzed through the Monte Carlo Analysis Method for Cost (Contingency) and Schedule (Escalation) Growth.


SAIL - CEPP Cost and Schedule Risk Analysis



SAJ - CEPP Cost and Schedule Risk Analysis

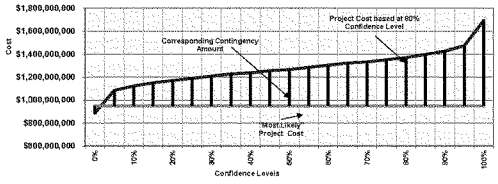
Contingency on Base Estimate	80% Confidence Project Cost
Baseline Estimate Cost (Most Likely) ->	$950,218,700
Baseline Estimate Cost Contingency Amount ->	$418,096,228
Baseline Estimate Construction Cost (80% Confidence) ->	$1,368,314,928

Contingency on Schedule	80% Confidence Project Schedule
Project Schedule Duration (Most Likely) ->	329.0 Months
Schedule Contingency Duration ->	89.0 Months
Project Schedule Duration (80% Confidence) ->	418.0 Months

- PROJECT CONTINGENCY DEVELOPMENT -

Contingency Analysis

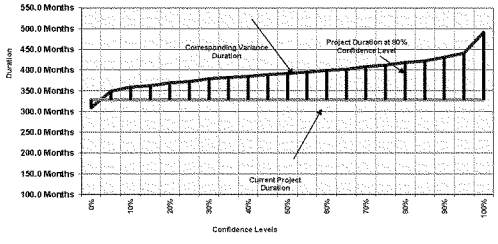
MCACES Estimate	$950,218,700		
Confidence Level	Project Cost	Contingency	Contingency %
0%	$883,703,391	($66,515,309)	-7%
5%	$1,083,249,318	$133,030,618	14%
10%	$1,121,258,066	$171,039,366	18%
15%	$1,149,764,627	$199,545,927	21%
20%	$1,168,769,001	$218,550,301	23%
25%	$1,187,773,375	$237,554,675	25%
30%	$1,206,777,749	$256,559,049	27%
35%	$1,225,782,123	$275,563,423	29%
40%	$1,235,284,310	$285,065,610	30%
45%	$1,254,288,684	$304,069,984	32%
50%	$1,263,790,871	$313,572,171	33%
55%	$1,282,795,245	$332,576,545	35%
60%	$1,301,799,619	$351,580,919	37%
65%	$1,320,803,993	$370,585,293	39%
70%	$1,330,306,180	$380,087,480	40%
75%	$1,349,310,554	$399,091,854	42%
80%	$1,368,314,928	$418,096,228	44%
85%	$1,396,821,489	$446,602,789	47%
90%	$1,425,328,050	$475,109,350	50%
95%	$1,472,838,985	$522,620,285	55%
100%	$1,691,389,286	$741,170,586	78%



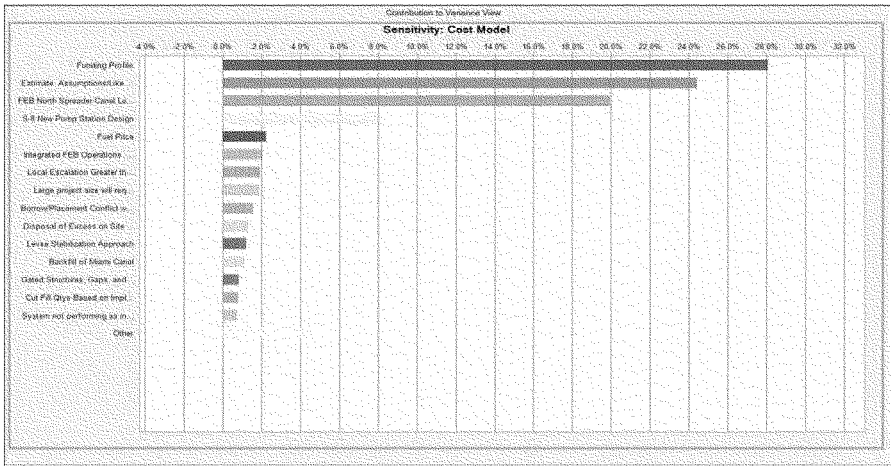
- SCHEDULE CONTINGENCY (DURATION) DEVELOPMENT -

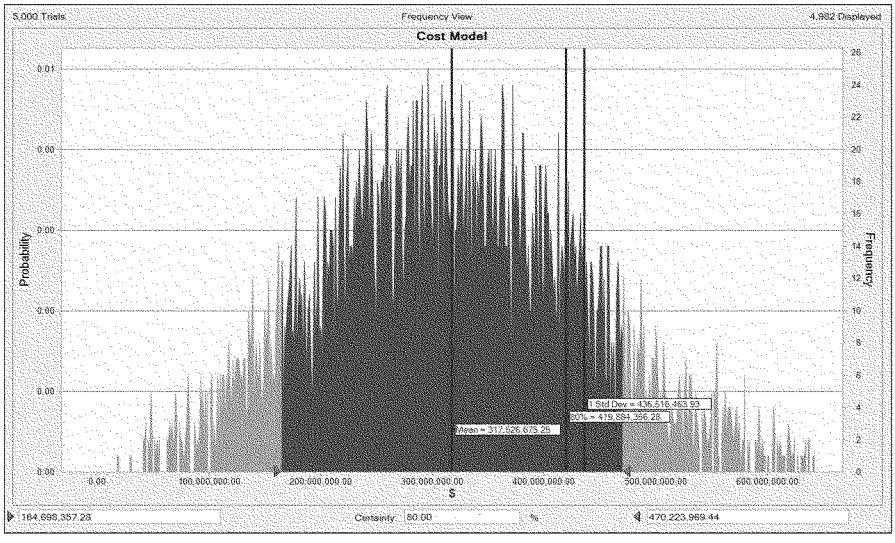
Contingency Analysis

Most Likely Schedule Duration	329.0 Months		
Confidence Level	Project Duration	Contingency	Contingency %
0%	309.0 Months	-20 Months	-6%
5%	349.0 Months	20 Months	6%
10%	359.0 Months	30 Months	9%
15%	362.0 Months	33 Months	10%
20%	369.0 Months	40 Months	12%
25%	372.0 Months	43 Months	13%
30%	379.0 Months	50 Months	15%
35%	382.0 Months	53 Months	16%
40%	385.0 Months	56 Months	17%
45%	389.0 Months	60 Months	18%
50%	392.0 Months	63 Months	19%
55%	395.0 Months	66 Months	20%
60%	399.0 Months	70 Months	21%
65%	402.0 Months	73 Months	22%
70%	408.0 Months	79 Months	24%
75%	412.0 Months	83 Months	25%
80%	418.0 Months	89 Months	27%
85%	422.0 Months	93 Months	28%
90%	431.0 Months	102 Months	31%
95%	441.0 Months	112 Months	34%
100%	491.0 Months	162 Months	49%

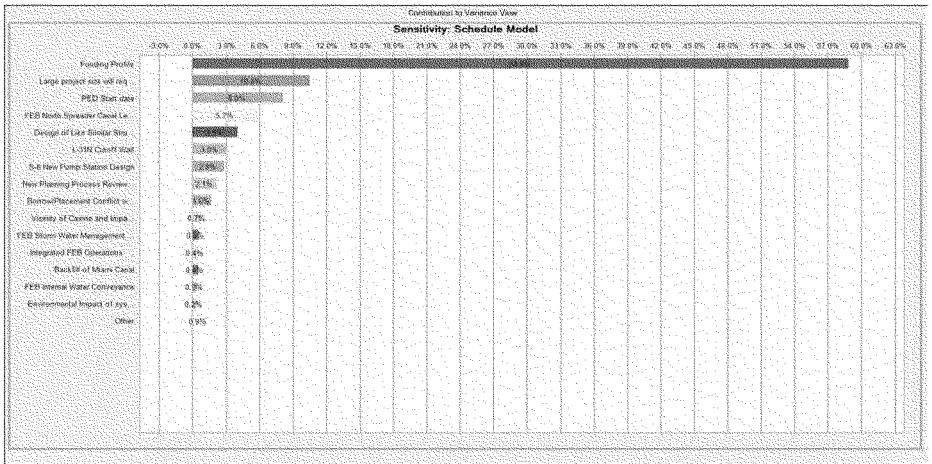


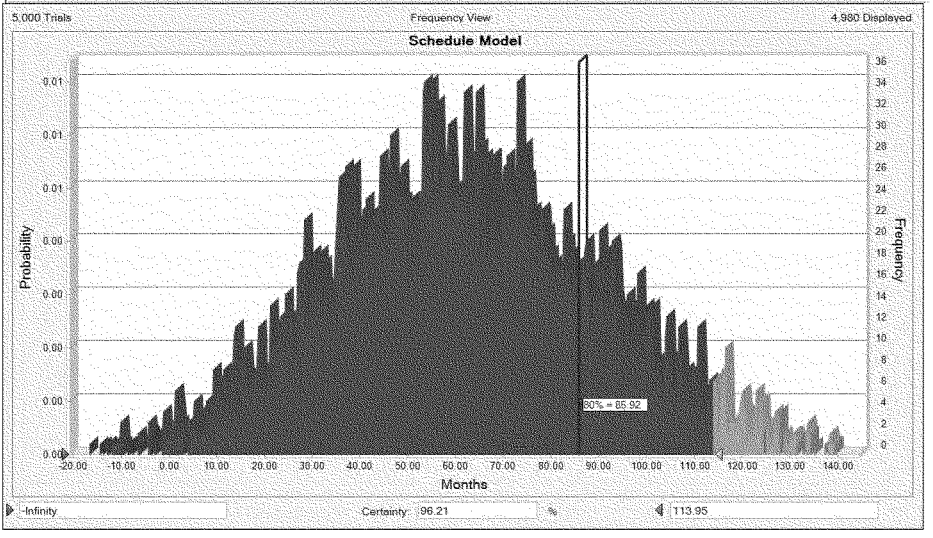
SAJ - CEPP Cost and Schedule Risk Analysis





SAJ - CEPP Cost and Schedule Risk Analysis





SNL - GEPP Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
P-PPR-1	New Planning Process Review Revisions	Very Likely	Negligible	LOW	Triangular	None	100%	$0	$0	$1,000,000	

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
P-PPR-1	New Planning Process Review Revisions	Likely	Marginal	MODERATE	Triangular	None	100%	0.0 Months	0.0 Months	12.0 Months	

Description:	As the project reaches mile stones and HQ revises or asks for changes to the process. The concern is during the 3x3x3 planning phase HQ revises the anticipated out come of the planning study and delays it the authorization schedule will be encountered.
Development of Low Values	The best case scenario is that the project moves forward with out any delays due to the new planning process. This will result in 0 months delay and will have no impact on the schedule.
Development of High Values	The worst case scenario is that the planning process is changed mid stream and additional requirements are added to the planning study. This will result in a cost of 12 months added to the schedule could add up to $1 million for study costs.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SALT CIPP Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlates	Correlation Factor	Low	Most Likely	High	Notes
P-PPM-2	Multiple overlapping projects	Very Likely	Significant	Risk#1	Triangular	None	100%	$0	$0	$0	

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
P-PPM-2	Multiple overlapping projects	Very Likely	Significant	Risk#1	Triangular	None	100%	0.0 Months	0.0 Months	0.0 Months	

Description	There are multiple overlapping projects and accounting for costs and benefits may be problematic. Overall benefits could be significantly overstated. There are numerous projects within the area that may have different purposes and overlapping features. This may cause accounting and authorization issues due to cost share and project purposes.
Development of Low Values	This risk must be addressed by HQ and the multiple project sponsors and is not studied. Savings Clause issues are assumed to be resolved and the project scope is assumed to be correct. NOT MODELED BUT CARRIED FOR WATCH LIST
Development of High Values	

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJU_GEPP_Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
P-PPR-3	PED Start date	Very Likely	Negligible	Low	Triangular	None	100%	50	50	58.3 Million	

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
P-PPR-3	PED Start date	Very Likely	Critical	High	Triangular	None	100%	0.0 Months	0.0 Months	24.0 Months	

Description	PED phase will most likely not start until next WRDA is passed. FY 2016 is probably the earliest authorization would occur. However this could change depending on the next WRDAs actual issuance.
Development of Low Values	
	The best case scenario is that construction starts as planned
Development of High Values	The worst case scenario is that the next WRDA is delayed and the project is delayed 2 years. The additional 24 months could be added to the schedule. This delay is after the report is routed and could expose the project to additional escalation as well as additional 50/51 work could to update and maintain the project data files. Assume 1/2 of one percent for two years cost.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CERP Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
P-PM-4	Funding Profile	Likely	Marginal	MODERATE	Triangular	None	100%	($36,021,870)	$0	$36,021,870	

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
P-PM-4	Funding Profile	Likely	Significant	HIGH	BETA P	None	100%	-38.5 Months	0.0 Months	6.5 Months	

Description	Project implementation is dependent on both the federal and sponsor being able to meet financial obligation to meet the project. Equal contributions or cost share from the sponsor and from USACE will be needed for future work. Progress could vary based on actual finical contributions in funding the project.
Development of Low Values:	The best case scenario is that the sponsor and the Corps are able to fund an additional 25% of the planned yearly cash contributions and that the schedule will act linear and reduce by 25%. It is assumed that this will have no effect on the overall project cost. Due to larger funding amounts, construction could be more efficient and be reduced up to 10%.
Development of High Values:	The worst case scenario is that the sponsor and corps are only able to fund 50% of the planned yearly cash contributions and the schedule will act linear and increase by 50%. It is assumed that this will have no effect on the overall project cost. The cost could increase by as much as 10% based on the extension of the schedule.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CEPP Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
NR-PR-A3	Integrated FEB Operations: A1 and A2	Likely	Negligible	MODERATE	Triangular	None	100%	$30,000,000	$0	$0	

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
NR-PR-A3	Integrated FEB Operations: A1 and A2	Likely	Negligible	LOW	Triangular	None	100%	0.0 Months	0.0 Months	6.0 Months	

Description	It is assumed that A1 will be completed prior to construction of A2 (Start FEB 2015 Completed 2018). Some minor changes in design or assumed operating conditions may result depending on final configuration of A2. This is an important risk element.
Development of Low Values	The best case scenario is that A1 is completed and the gated culverts in the project is no longer needed and the cost for the structure will be a savings of approx $15.5M. Assumed that one of the gated structures is no longer needed as this is concurrent work it will not have a savings for schedule. Another case scenario is that savings that could be realized range from zero (if another structure is needed) to the most likely value of the A1 FEB. The total could be the 7 miles of shared levee will be $33.2e Million with a savings in schedule.
Development of High Values	The worst case scenario is that it takes up to 6 months to determine through planning that the structure is not needed and that could cause a slip in the schedule due to having to remodel the entire project multiple times to fully understand the benefits of each feature with no added cost.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CEPP Cost and Schedule Risk Analysis
Description
When dealing with large multiple year projects there are concerns for localized inflation above CWCCIS. The concern is that due to funding restrictions and multiple contracts that inflation in CWCCIS will be underestimated in future years. This is the possibility that inflation exceeds the CWCCIS tables in future years.
Development of Low Values
The best case is that CWCCIS captures the actual local inflation accurately.
Development of High Values
The worst case scenario is that CWCCIS will not account for the actual inflation. Based on the current average inflation of ~3%, for out years, this could be 1/4% low for the total construction costs in the long term. It is assumed that this will have no impact on the schedule.
Cumulative Probability Assumption Chart - Cost
Lead Estimate Greater than Midpoint Average
Frequency
Probability
Cumulative Probability Assumption Chart - Schedule

SAJV - CEPP Cost and Schedule Risk Analysis
Description
Most likely due to the large size of the project the project will be broken up into small individual contracts. Construction and sequencing may change significantly due to acquisition approach. Sema thought has been put into contract acquisition into base case estimate. However schedule and cost could change significantly based on contract acquisition approach.
Development of Low Values
The most optimistic scenario is that the schedule will be reduced into single then anticipated correct resulting in lower implementation costs and lower overhead on the project. This potential savings will be realized based on saving 6% on 20% of the work. Based on scheduling fewer projects and contracts awarded. Schedule value is based on 37 features of work; results in 8 contracts saving one month each
Development of High Values
The worst case scenario is that the features are awarded individually or even broken into smaller contracts than anticipated resulting in increased overhead and implementation costs. There is a construction cost risk on 20% of the work. Based on scheduling multiple smaller contracts award dates dependent on work under another contract it is assumed that for 2 additional months per contract could be needed on the additional 20% resulting in 8 contracts taking 16 additional months.
Cumulative Probability Assumption Chart - Cost
Large project size will require multiple projects
Frequency
Cumulative Probability Assumption Chart - Schedule
Large project size will require multiple projects
Frequency

SAJ - CEPP Cost and Schedule Risk Analysis
Description
Concern for scoping of projects to ensure that the backfill and excavation and structure modifications are in the same contract. L5 - L5 must be completed together along with modifications to S-9 and Miami back fill are all required to be completed in series. This could affect construction cost and schedule.
Development of Low Values
The best case scenario is that all construction features are excavated for correctly and will have no added costs. This is a case where there is no chance to save costs.
Development of High Values
The worst case scenario is that all work must be completed in one contract and that the material required from onsite excavations will not be available. This will result in additional costs for importing fill and also additional costs for disposing of material. This is only referring to work at the L5 structure. The worst case for the L5 structure would be if it was required to backfill the Miami canal it could add an additional $45 Million. This will also lengthen the schedule. The schedule will need up to 12 months based on future scheduling and supply and demand for material.
Cumulative Probability Assumption Chart - Cost
Borrow/Placement Conflict with Multiple Contracts
Probability
Frequency
Cumulative Probability Assumption Chart - Schedule
Borrow/Placement Conflict with Multiple Contracts
Probability
Frequency

SAJ - CEPP Cost and Schedule Risk Analysis

Cost

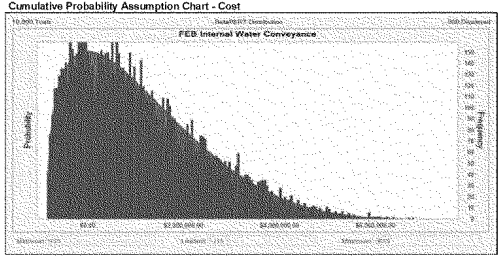
Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
NR-TL-3	FEB Internal Water Conveyance	Very Likely	Marginal	MODERATE	Beta Pert	None	100%	($850,000)	$0	$7,500,000	

Schedule

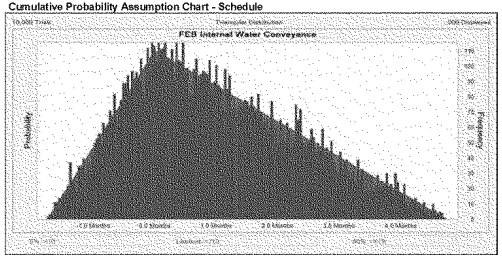
Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
NR-TL-3	FEB Internal Water Conveyance	Very Likely	Marginal	MODERATE	Triangular	None	100%	-1.0 Months	0.0 Months	3.0 Months	

Description	There are existing AG canals in the proposed location of the FEB along with roads bordering each side of the canal that may cause issues. There is the possibility of piping through the proposed location of the perimeter levee. There is also the concern for not allowing sheet flow across the FEB with out backfilling or plugging the AG canals.
Development of Low Values	The best case scenario is that the AG canals will act as a conveyance method for draining the FEB and less work will be needed for the outflow canal. Assume that this reduces to cost and duration of the outflow canal by 10%.
Development of High Values	The worst case scenario is that additional work will be needed to ensure that sheet flow will be maintained across the FEB. This could include backfilling the AG canals or plugging the canals. Assume this could add an additional $7.5 Million to the project and 3 months.

Cumulative Probability Assumption Chart - Cost



Cumulative Probability Assumption Chart - Schedule



SAJ - CEPP Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
HR-1-4	FEB North Spreader Canal Length	Likely	Marginal	MODERATE	Triangular	None	100%	$0	$0	$5,500,000	

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
HR-1-4	FEB North Spreader Canal Length	Likely	Marginal	MODERATE	Triangular	None	100%	-12.0 Months	0.0 Months	10.0 Months	

Description	Currently the spreader canal is only on part of the northern end of the FEB. There is concern that the canal my need to extend along the entire northern end including routing the spreader canal south and east to hydrate the east end of the FEB. This will lengthen the canal and additional costs and based on limited design assess will add additional time to the schedule.
Development of Low Values	The best case scenario is that during design it is determined that the length, depth and width can be varied to reduce the overall excavation to achieve a net zero cut fill balance. This could reduce the costs if excavation by 90.2% or by $85.3 million and shorten the duration by 12 months.
Development of High Values	The worst case scenario is that the excavation length is required full width and depth to extend to the eastern most extent of the FEB adding an additional 3 miles to the length of the canal. This would add an additional $81.3 million to the project and lengthen the schedule by 10 months.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CEPP Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
RR-TC-5	FEB Porosity of Lime Rock is Unknown	Likely	Marginal	MODERATE	Triangular	None	100%	$0	$0	$14,670,000	

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
RR-TC-5	FEB Porosity of Lime Rock is Unknown	Likely	Marginal	MODERATE	Triangular	None	100%	0.0 Months	0.0 Months	2.9 Months	

Description	There is the concern that the Lime rock is not capable of containing the water. Unknown geotechnical data. There is concern that there could be a need to be additional work under the FEB perimeter levee. A1 will be constructed prior to A2 and may provide some forewarning of issues.
Development of Low Values	The best case scenario is that the lime rock in the area of the FEB is at the anticipated depth of 15 ft. It would also be best case that the lime rock will not require any additional work to ensure that seepage is resolved. This results in the estimate as the best case for development of low values.
Development of High Values	The worst case scenario is that additional excavation is required to reach limestone for the base of the levee. It is assumed that one ft of additional excavation could be required to reach the limestone layer. This could also increase the schedule. It would also be worst case scenario that the lime rock would require work to ensure seepage and stability. It is assumed that this work could increase the cost of the perimeter levee base excavation and backfill would go up to 80% and an additional 20% for work required to ensure minimal seepage for a 100% increase in cost of excavating and backfilling the excavation.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CSRP Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
SR-TL-5	S-8 Flood Control Operations	Likely	Marginal	MODERATE	Triangular	None	100%	$0	$0	$14,255,231	

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
SR-TL-5	S-8 Flood Control Operations	Likely	Marginal	MODERATE	Triangular	None	100%	0.0 Months	0.0 Months	1.5 Months	

Description	S-8 needs to provide flood control the entire time until downstream work is complete. A plan and appropriate costs have been incorporated in the features effected by the operation of the S-8 pump station. This includes the gated culverts down stream of the pump station including diversion canals. If any additional work is needed to ensure flood protection it will cause additional cost and could lengthen the schedule.
Development of Low Values	The best case scenario is that no additional work will be required to maintain flood control during construction.
Development of High Values	The worst case scenario is that additional work will be required. It is unknown at this time the additional work that may be required it is assumed that it could total 1.5% of the total project cost it is assumed that the schedule will have the same delay.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CEPP Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
SR-1C-7	S-8 New Pump Station Design	Likely	Crisis	High	Triangular	None	100%	$0	$0	$100,000,000	

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
SR-1C-7	S-8 New Pump Station Design	Likely	Negligible	LOW	Triangular	None	100%	0.0 Months	0.0 Months	12.0 Months	

Description	The current plan is unclear on the status of S-8 Pump Station. This could require actions ranging form full replacement to minor modifications. The Engineering appendix does not provided sufficient information to determine what the new design of the S-8 pump station. It is likely that the pump station will need additional work to ensure that the pumps are capable of handling the flood waters. this could range from a new pump station to a retrofit of the existing.
Development of Low Values	The best case scenario is that no additional work will be required to complete the effort.
Development of High Values	The worst case scenario is that a new pump station will be required to be constructed. Based on the location of the pump station and the features that are being built in the area the work required to complete the new pump station could cost as much as $100 Mil based on the estimated cost of the S-8 Pump Station. The high schedule impact is based on the work taking 1 year to award based on funding restraints.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAU - CEPP Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
SR-TL-9	G-336d Capability to Increase	Likely	Marginal	MODERATE	Triangular	None	100%	$0	$0	$12,500,000	

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
SR-TL-9	G-336d Capability to Increase	Likely	Negligible	LOW	Triangular	None	100%	0.0 Months	0.0 Months	3.0 Months	

Description	Usability of existing structure is in question. There is the possibility that the structure has more capability and will need little to no work. However if additional work is required there would be a need for additional costs.
Development of Low Values	The best case scenario is that there is no need for additional work.
Development of High Values	The worst case scenario is that the structure needs work resulting in a new feature being built. It is assumed that this feature could be similar to S-353N with a similar duration and construction costs.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CEPP Cost and Schedule Risk Analysis

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
BCT-15	Tamiami Trail Bridges and Roads Raise	Unlikely	Crisis	HIGH	N/A	N/A		0.0 Months	0.0 Months	0.0 Months	

Description	This work needs to be completed prior to CEPP and needs to be completed for project to operate as designed. Current scheduled completion dates for these features need to be considered in the implementation schedule for this project. If they are not completed they could likely would delay the CEPP project completion.
Development of Low Values	This risk would not necessarily delay the completion of the project but would delay the benefits by some duration. This risk is not modeled as it is assumed that the bridge raise will be completed
Development of High Values	

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CEFP Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
BC-1C-20	De-Comp Physical Model Results	Unlikely	Significant	MODERATE	Triangular	None	100%	$0	$0	$15,000,000	

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
BC-1C-20	De-Comp Physical Model Results	Unlikely	Significant	MODERATE	Triangular	None	100%	0.0 Months	3.0 Months	9.0 Months	

Description	There is the possibility that the de-comp model will change the design of some or all features in SFC. Could need to be backfilled or plugged as a result of the de-comp model results. There is also the possibility that additional features could be identified as a result of the model results. May be difficult or impossible to model. Current report is based on best known information. This should be included on the watch list of risks.
Development of Low Values	The best case scenario is that once the model is finalized there is no additional work required to endure the desired flow is achieved.
Development of High Values	The worst case scenario is that additional cost and schedule will be required to backfill the canal and accommodate the changes in the design of the features in the area. It is assumed that the additional backfill could add $5 mil to the project and the feature modifications could add $10 mil additional work in the Blue-Green-Yellow line area. This is not included under the USACE's management estimate.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - GEPP Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
BC-TC-21	Collector Canal at S-3558	Likely	Marginal	MODERATE	N/A	N/A		$0	$0	$0	

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
BC-TC-21	Collector Canal at S-3558	Unlikely	Marginal	LOW	N/A	N/A		0.0 Months	0.0 Months	0.0 Months	

Description	There is concern that there could be the need for a collector canal at the location of the current S-3558. This is not included in the current construction estimate or scope. It will allow for the water to be drained out of the WCA-3B. The cost for a collector canal at S-3558 is included in the alternative management lease costs. This is not included in the 'yes' as the costs in the alternative management lease costs.
Development of Low Values	The best case scenario is that no collector canal is needed. No credit is assumed.
Development of High Values	

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SJVJ - CEPP Cost and Schedule Risk Analysis

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
V-11-26	S-356 New Pump Station Design	Very Likely	Marginal	MODERATE	Triangular	YLD-16	100%	50	90	$8,550,000	

Description	It is unknown about the buy in from the tribes in the design, Noise, design of structure, and vibrations generated from pumps around tribal lands have been an issue in the past. There is concern for the proximity to the casino owned by the Wiconsaltee tribes. This may drive the design to be esthetic pumps or require additional aesthetics to counteracting factors.
Development of Low Values	The best case scenario is that pumping plant needs no changes.
Development of High Values	The worst case scenario is that additional changes could add 1/3 to the cost of this pump station.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CEPP Cost and Schedule Risk Analysis

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
BCT-27	Blue Sheerly Levee Foundation	Likely	Marginal	Moderate	Triangular	None	100%	$0	$0	$19,500,000	

Description	There is little to no data in the area of the levee. The need for upgrades to the foundation design may be needed; this would ensure that there was minimal piping under the levee. The future design could include the use of filter blankets to ensure the stability of the levee foundation.
Development of Low Values	The best case scenario is that through investigations it is determined that no additional work is needed to stabilize the levee base.
Development of High Values	The worst case scenario is that filter blankets and or other work is needed to ensure that there is minimal piping under the levee this could add an additional 25% to the levee cost.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAU - CEPP Cost and Schedule Risk Analysis

Risk Reference/ No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
IL-28	Global Geo Tech Assumptions	Likely	Significant	High	Triangular	None	100%	[illegible]	$0	$11,455,000	

Description	The team used global assumptions for the material strata for entire project although past experience shows that these can vary significantly throughout the region. Any localized variance in the material type could have an impact on the cost of excavation.
Development of Low Values	Currently the material strata for the entire project is set the same. There is the possibility that the material encountered during construction could be easier than expected. Assume that 5% of the entire site will encounter softer material, such as sand or mixed-seeded formation. This will reduce the unit cost on 270,000 BCY by approximately $3 per BCY.
Development of High Values	Currently the material strata for the entire project is set the same. There is the possibility that if the material encountered during excavation is different than expected this could add additional cost. Assume that up to 25% of the blasted material is harder requiring slower production and more blasting. We have assumed 5% more blasted material with an additional 15% price increase per BCY for harder excavation and an additional 775,000 BCY of blasted excavation at approximately $9 per BCY more.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CEPP Cost and Schedule Risk Analysis

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
TC-29	Disposal of Excess on Site Material	Very Likely	Significant	High	Triangular	None	100%	$0	$0	$39,000,000	

Description	
	Currently there is no design for location or technique of onsite disposal of excess material. There is likely the chance that additional work will be required to usefully dispose of the material on site. This could range from spreading across areas to increasing bin size of earthen features.
Development of Low Values	The best case scenario is that no additional work will be needed to dispose of the material on site. The material can just be stockpiled.
Development of High Values	The worst case scenario is that additional work will be need to move and shape 40% the 6.5 million LCY around the FEB and create swales, berms, or build bigger levees. The estimate for moving the material is $39 million

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

Risk Reference
No.
1.30
Risk Event
Levee Stabilization Approach
Likelihood
Unlikely
Impact
Crisis
Pert-Level
Distribution
Triangular
Correlation
None
Correlation
Matrix
100%
Low
$4
Most Likely
$9
High
$24,450,000
Notes
Description
Currently the estimate has seeding as the means of stabilization for the side slope of the levee. Possible risks exist in terms of establishing and maintaining an adequate stand to ensure the stabilization of the levee. In that case the levee might need to be covered in sod.
Development of Low Values
The best case scenario is that the levees and stabilization can be seeded or hydro seeded. This will result in no change to the estimate in cost or schedule.
Development of High Values
The worst case scenario is that the levees and stabilization will need sod used in the stabilization process. In this case the estimate has been modified and it adds an additional $24.45 Million to the cost. It will not add any additional time to the project.
Cumulative Probability Assumption Chart - Cost
Cumulative Probability Assumption Chart - Schedule

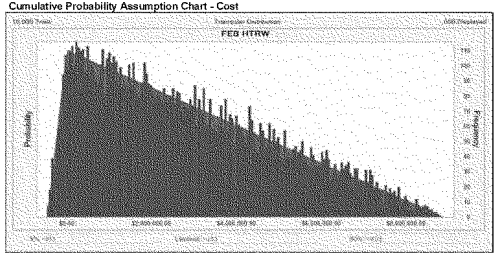
SAIC CEFPP Cost and Schedule Risk Analysis
Risk Reference No. TL-31
Risk Event
System not performing as intended
Likelihood
Likely
Impact
Critical
Risk Level
High
Distribution
Triangle
Correlation
Manual
Correlation Factor
100%
Low
90
Most Likely
90
High
$42,935,535
Notes
Description
There is a technical risk that the system may not perform as expected and that some additional work may be required.
Development of Low Values
Assume the base case estimate is same as the low value
Development of High Values
Assume that up to 5% of the estimated construction cost could be expended performing changes to the project to make it perform successfully.
Cumulative Probability Assumption Chart - Cost
System not performing as intended
Frequency
Probability

SAJ - CEPP Cost and Schedule Risk Analysis

	Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
Cost	NR-LD-1	FEB HTRW	Very Likely	Marginal	MODERATE	Triangular	None	100%	$0	$0	$6,000,000	
Schedule	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Description	There is the possibility that the Farm Land may have HTRW in the area. There is likely an area or areas that will need additional work to ensure that the area is free of hazardous material prior to starting the construction of the FEB.
Development of Low Values	The best case scenario is that no HTRW will be found in the area.
Development of High Values	The worst case scenario is that HTRW is found. It is assumed that this would not delay the critical path. Costs for the HTRW are the sponsors responsibility but are included in the TPC and cost share. It is assumed that this could add an additional 6M to the project.

Cumulative Probability Assumption Chart - Cost



Cumulative Probability Assumption Chart - Schedule

SAJ / CEPP Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
BC-LC-3	Mitigation of Lands	Unlikely	Marginal	LOW	N/A	N/A		$0	$0	$0	

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
BC-LC-3	Mitigation of Lands	Unlikely	Significant	MODERATE	N/A	N/A		0.0 Months	0.0 Months	0.0 Months	

Description	The concern is that not all lands necessary to complete the project will be acquired by other projects along Tamiami trail. There is a risk that some lands targeted to be acquired by other projects may not be timely or be acquired due to funding. This could delay the project.
Development of Low Values	The best case scenario is that the other agency that is required to acquire the land will do so in a timely manner and it will not be an impact. The project can move forward without a delay.
Development of High Values	The worst case scenario is that the other agency will not acquire the lands in a timely manner potentially delaying implementation in the area. This could delay the project in the interim but not affect the overall critical path and final completion date. This will not be modeled.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAN_CEPP Cost and Schedule Risk Analysis

Risk Reference no.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
Y-LS-10	Lands for New Pump S356	Likely	Marginal	MODERATE	Triangular	Y-TL-26	100%	50	50	$3,825,000	

Description	The current location of the new pump is in the general proximity of the Milwaukee tribal area. Depending on the future state of S-356 a new location may be beneficial to acquire new lands for construction of the replacement. It is unknown if the temp pump will be used during construction, it also is unknown if the proposed location of the new pump will allow for the pump station to be able to be constructed while still operating the existing S-356 pumps.
Development of Low Values	The best case scenario is that the existing 356 pump station will remain operational as needed during construction, the new 356 pump station can be built on lands that do not need to be acquired in the same vicinity as the existing 356 pump station. No additional costs will be encountered.
Development of High Values	The worst case scenario is that temporary pumping will be needed and a new location for the pump station will be required. This could impact the cost of construction up to 15% of the cost of the new S-356 pump station. This would also require additional lands to be acquired for a different location. This is inversely correlated to Y-TL-26 i.e. if I redesign for noise, I don't need to move it but if I move it I don't need to consider the desing/noise issues.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CEPP Cost and Schedule Risk Analysis

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
RE-2	Water Quality Legal Issues Project Wide	Unlikely	Crisis	HIGH	N/A	N/A		0.0 Months	0.0 Months	0.0 Months	

Description	Water quality in system has been challenged before. It is assumed that this will be resolved and water quality will be acceptable prior to the construction of <CEP>. Legal action or delays could significantly delay the project if this is not resolved the project will not move forward, this issue must be resolved prior to authorization of this project.
Development of Low Values	This risk will not be modeled. It is assumed that the water quality issues will be resolved prior to authorization as this would stop the project
Development of High Values	

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CEPP Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
SC-RE3	Environmental Impact of system L67C	Likely	Significant	HIGH	Triangular	None	100%	$0	$0	$6,250,000	

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
SD-RE4	Environmental Impact of system L67C	Likely	Marginal	MODERATE	Triangular	None	100%	0.0 Months	0.0 Months	2.0 Months	

Description	NEPA Impacts of changing the affected area needs to be considered. It is unclear if the areas and volumes will ensure a net positive effect. It is unclear if the first print of impact to the system will be equal after construction. The initial documentation included for removing the L67C and backfilling the canal is complete however actual results could change the plan.
Development of Low Values	The best case scenario is that no additional work is needed to satisfy the NEPA requirements.
Development of High Values	The worst case scenario is that we would have to remove material from L67C pond or build a spreader canal. Use approx 1.5 times the cost to fill in L67 EXT and 2 months.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CEPP Cost and Schedule Risk Analysis

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
BC-RE-13	Tree Island North of Osceola	Likely	Marginal	MODERATE	Triangular	None	100%	30	50	$8,000,000	

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
RE-13	Tree Island North of Osceola	Likely	Marginal	MODERATE	Triangular	None	100%	30	50	$8,000,000	

Description	There are historically significant tree islands north of Osceola Camp. These islands cannot be affected by construction or removal of the project. There is a potentially sensitive cultural site just north of the Osceola camp.
Development of Low Values	The best case scenario is that studies will show that there will be no need for additional protection around the Tree islands that have historically significant items.
Development of High Values	The worst case scenario is that additional work will be needed to ensure that the tree islands are not affected by the project. The addition cost of adding a rock berm around the island or building a ring levee to armoring the exterior of the island or rerouting the outflow canal from the new S-333 N structure around the island. Costs are based on routing the outflow canal around the island effectively adding three times the length of the canal to the current project.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAM CERP Cost and Schedule Risk Analysis

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
P-CON-1	Fuel Price	Likely	Significant	Slight	Uniform	None	100%	$0	$0	$66,600,000	

Risk Reference No. P-CON-1 | Risk Event: Fuel Price | Likelihood: Likely | Impact: Significant | Risk Level: Slight | Distribution: Uniform | Correlation: None | Correlation Factor: 100% | Low: $0 | Most Likely: $0 | High: $66,600,000 | Notes:

Description	Due to the large quantity of hauling that will take place on the job there is a chance that fuel prices increasing could impact the job. It is unknown at this time what the future of fuel prices will do, this will be studied and determined what different increases in how fuel prices will effect the job.
Development of Low Values	The best case scenario is that fuel prices will maintain current inflation with CWCCIS. This will result in no change for this low value.
Development of High Values	The worst case scenario is that fuel prices will increase at the same rate as the last 10 years (the highest rate recorded by CWCCIS) and that the fuel prices during the 3 year construction period fuel could increase from $119.1 million to $184.8 million to the midpoint of construction.

Cumulative Probability Assumption Chart - Schedule

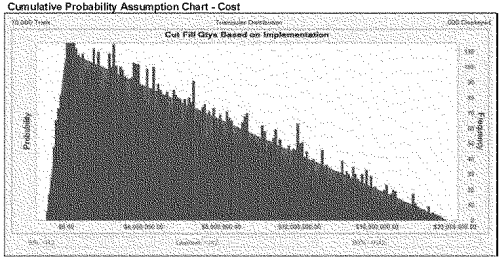
SAJ - CEPP Cost and Schedule Risk Analysis

	Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
Cost	NR-CON-4	Cut Fill Qtys Based on Implementation	Very Likely	Marginal	MODERATE	Triangular	None	100%	$0	$0	$13,250,000	

Schedule	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Description	Cut/Fill quantities could vary from estimate. The concern is that you will need off site borrow or to create an excavation pit to ensure that all features have sufficient material. Additional processing of onsite materials as needed. This could also change based on implementation.
Development of Low Values	The best case scenario is that all projects are completed in a logical manor that delivers material for construction and benefit with eliminating any need for offsite fill.
Development of High Values	The worst case scenario is that the sequencing of benefits outweighs the construction scheduling for a net cut-fill balance and will require off site fill to complete features of work. FEB perimeter levee is required prior to construction of the C-625E. Assumed that off site material could be needed for 25% of the levee adding an additional $13.25 million

Cumulative Probability Assumption Chart - Cost



Cumulative Probability Assumption Chart - Schedule

SAL1: CEPP Cost and Schedule Risk Analysis
Description
The concern is that there will be water influx to the area during a storm. There is the possibility that the water could be a hazard or delay to the work. There is concern that it will affect the process of scheduling the work there will be delays that adversely impact the operations of the features.
Development of Low Values
The best case scenario is that there are no storms that impound water in the FEB prior to the system being operational. This will cause no delays or no additional costs. This can be achieved by scheduling of contracts, and possible staged construction.
Development of High Values
The worst case scenario is that there is a major storm that impounds the FEB and systems are not operational to empty the system. This will likely add an additional year to the construction and $25 million for reconstruction of damaged features, overhead and the costs for dewatering the FEB. Use 4 years construction, 1/100 storm probability and 25M for delayes.
Cumulative Probability Assumption Chart - Cost
FEB Storm Water Management during Construction
Frequency
Cumulative Probability Assumption Chart - Schedule

SAJ - CERP Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
SFCOST-3	Backfill of Miami Canal	Very Likely	Marginal	MODERATE	Triangular	None	100%	$5	$9	$7,500,000	

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
SFSCH-3	Backfill of Miami Canal	Very Likely	Marginal	MODERATE	Triangular	None	100%	0.0 Months	0.0 Months	6.0 Months	

Description	There is concern for sequence of construction when backfilling the Miami Canal. The concern is that the project will extend over multiple years and there will be a need for culverts, plugs, extra work that is not currently in the estimate. Funding and project schedule could impact this considerably.
Development of Low Values	The best case scenario is that the L-4 degrade and the work for new gated culverts at S-9 will be complete prior to backfilling the Miami canal and no additional work will be needed to maintain canal capacity with Lake Okeechobee. This would also be required for the schedule.
Development of High Values	The worst case scenario is that additional culverts would be required at the S-9 structure, spoils mounds and every other gap will need a culvert costing $50 k to install and remove. With the canal having 150 mounds per side totaling 150 culverts needed to drain the Miami canal in the case that the modifications are not complete. The additional work could add up to 6 months to the schedule.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CEPP Cost and Schedule Risk Analysis

	Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
CSD	BC-CON-11	Blue Shanty Levee Construction	Likely	Marginal	MODERATE	Triangular	None	100%	$0	$0	$16,000,000	

	Description
	Sequencing could cause borrow/fill issues. Flood protection will be required during construction. It is not likely that L-29 can be removed prior to construction of the blue shanty flow way dikes.
Development of Low Values	The best case scenario is that some of the material from the L-29 can be used. This could reduce the overall cost. The cost of L-29 removal is not known at this time but is considered so minimal that it will not be used in development of the low value.
Development of High Values	The worst case scenario is that all material for the blue shanty flow way levee must be obtained from an off site source. This could add an additional $16 million based on the qty needed.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CEPP Cost and Schedule Risk Analysis

Description	
	Nearby Casino may be sensitive to noise and or vibrations from construction. The construction contractor may be impacted due to concern of vibrations from the Casino nearby. This could cause restrictive construction windows placed on the contractor.
Development of Low Values	The best case is that there is no impact on the construction schedule based on the location of the structure. Deliveries and work can commence as planned and will not be impacted.
Development of High Values	The worst case scenario is that the proximity to the casino will restrict work windows, delivers, and or materials leaving the job site. These factors combined could affect project production and increase the duration of construction for the pump station. Assumed an additional 6 months based on restrictive work windows.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

Vicinity of Casino and Impacts of Construction

SAJ - CEPP Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
Y-ES1-10	L-31N Cutoff Wall	Very Likely	Significant	Slight	Triangular	None	100%	$3,500,000	$5	$19,900,000	

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
Y-ES1-10	L-31N Cutoff Wall	Very Likely	Significant	Slight	Triangular	None	100%	0.5 Months	12.5 Months	12.5 Months	

Description	There is reason to believe that information gathered from the miners cutoff wall will change the current location of the cutoff wall. Currently the cutoff wall is planned to be located on the bench between the levee and the canal. This location may change adding additional depth based on the results from the miners wall additional depth or length may be required to achieve the proper effects. Quantity could be as little as 2 extra miles of cutoff wall, but could
Development of Low Values	The best case scenario is that based on demonstrations from the miner's cutoff wall it is shown that the CEPP could retain the short reach to 2 miles.
Development of High Values	The worst case scenario is that based on demonstrations from the miner's cutoff wall the length and or depth will need to be increased. The team is aware that the cutoff wall may need to be relocated to the top of the levee adding an additional 50% to the depth, in addition there could be the need for additional length requiring the cutoff wall to be a total of 100% bigger by square footage.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CEPP Cost and Schedule Risk Analysis
Risk Reference No.
ES-T1
Risk Event
Labor Rates
Likelihood
Likely
Impact
Marginal
Risk Level
MODERATE
Distribution
Triangular
Correlation
None
Correlation Factor
100%
Low
$0
Most Likely
$0
High
$17,400,000
Notes
Description
Local wage rate assumptions could very from assumed and impact the estimate. Generally wages are low in the area however skilled workers generally can command higher wages relative to more unskilled labor rates. Wage rates in estimate are based on local market research and are current
Development of Low Values
Wage rates in the area are generally lower than the rest of the US and the Davis Bacon act wages are generally low in comparison. The estimate uses average BLS wages or the Davis Bacon wages and are generally the MINIMUMS
Development of High Values
Skilled and specialty workers could command a premium in the local market place for skill sets such as millwrights, electricians, etc. Assume that the skilled labor required for significant portions of the construction activities will be at a premium. Assume that the wages in the estimate fall in line with past labor rates there is a concern that the skilled workers building features in CEPP may be making much more then local rates. If the wage rates are $2 per hour low that could add an additional $17.4 million
Cumulative Probability Assumption Chart - Cost
Labor Rates
Frequency
Cumulative Probability Assumption Chart - Schedule

SAJ - CEPP Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
EST-12	Design of Like Similar Structure	Likely	Marginal	MODERATE	Triangular	None	100%	$24,313,330	$0	$29,721,870	

Schedule

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
EST-12	Design of Like Similar Structure	Likely	Marginal	MODERATE	Triangular	None	100%	-6.6 Months	0.0 Months	12.0 Months	

Description	That features were estimated using plans from similar structures with minimal design for the CEPP feature. The assumption that local like similar features would be adequate to capture the necessary scope. Features may require additional scope that was not identified in the similar feature. Additionally the estimators had to make significant assumptions since development of the quantities to complete the cost estimate.
Development of Low Values	The best case scenario is that the similar structures are over designed compared to the features for CEPP in both qty and scope. This could lead to a reduction in costs and schedule of 5% across the board.
Development of High Values	The worst case scenario is that the similar structures are under designed compared to the features for CEPP in both qty and scope. This could result in an increase of costs and schedule of 10% across the board.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CEPP Cost and Schedule Risk Analysis

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
BCPL-2	L-87 Recreation Access	Likely	Marginal	MODERATE	Triangular	None	100%	$0	$0	$6,000,000	

Description	Access for existing recreation features may need to be changed due to project construction. Some costs for relocating the recreation access to the L-87C and L-87A are included in the cost estimate, however, the additional recreation access may be needed and that improvements to existing levels to allow for vehicle access may be needed.
Development of Low Values	The best case scenario is that the current recreation plan is sufficient to cover the anticipated needs for recreation.
Development of High Values	The worst case scenario is that the recreation plan needs additional funding to allow for alternative recreation features. The worst case is that additional recreation features are needed (ie. trail, turnouts, paving or any combination of the above. The cost is assumed it could add an additional 6M to the construction cost. The schedule will not be impacted as the recreation is not considered critical path construction

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CEPP Cost and Schedule Risk Analysis

Description	There is the possibility that the three gated structures in L-67A, levee removal and gain in L-67C and L-67 extension removal are included in another authorized project Costs for 3 gated structures, levee removal, L-67C and L-67 extension removal are not included in the costs of this project. If it is determined that they should not be included, their cost will be considered an opportunity.
Development of Low Values	The best case scenario is that another authority has committed to covering the costs of the L-67A structure and the L-67C gaps and removal. This could result in a savings of $20.3 million
Development of High Values	The worst case scenario is that no other authority has already committed to covering the cost of this work and will be incorporated in the cost of CEPP.

Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

SAJ - CEPP Cost and Schedule Risk Analysis

Cost

Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
PR-8	Close Out of Other Projects	Likely	Marginal	MODERATE	N/A	N/A		$0	$0	$0	

Schedule

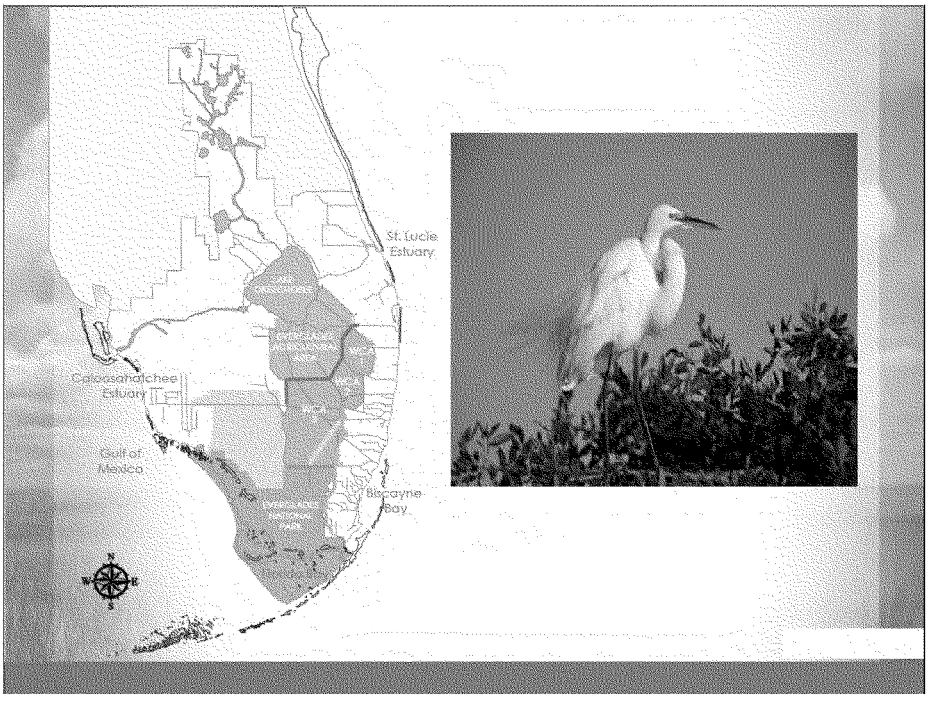
Risk Reference No.	Risk Event	Likelihood	Impact	Risk Level	Distribution	Correlation	Correlation Factor	Low	Most Likely	High	Notes
PR-8	Close Out of Other Projects	Likely	Significant	HIGH	N/A	N/A		0.0 Months	0.0 Months	0.0 Months	

Description	HQ has not provided final confirmation that Mod-Waters will be closed out. Prioritization and closeout of the project could affect the execution schedule. This effect could substantially change the project formulation and execution schedule. This risk will be noted but not modeled.
Development of Low Values	This is a case where features will change and or structures could be incorporated based on final close out of another authorization. This will be noted and maintained on the risk watch list register but will not be modeled.
Development of High Values	

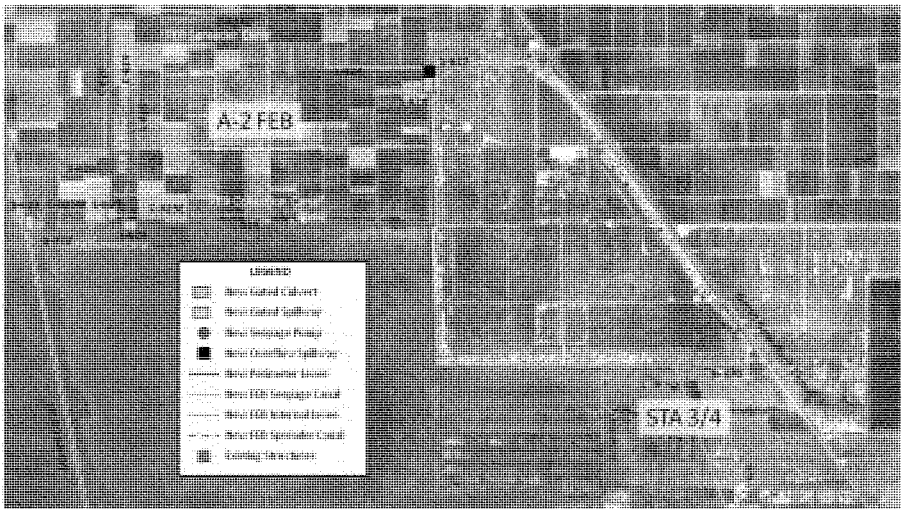
Cumulative Probability Assumption Chart - Cost

Cumulative Probability Assumption Chart - Schedule

CEPP Cost Estimate Scope Assumptions, Representative Drawings and Quantity Takeoffs



North of the Redline – Storage and Treatment Flow Equalization Basin A-2 (FEB)



Feature of Work:	FEB - S-623 (DS-8) Gated Spillway 3700 CFS in 3/4 Canal

Scope Given:	The S-623 spillway will serve as a divide structure to separate pre-treated FEB waters from untreated waters of the Miami Canal to maximize incidental water quality value of the flow-through impoundment. When open, S-623 will allow for the normal operations of the G-372 pump station to route Miami Canal water, or when closed can be use to route pre-treated FEB water through the STA 3/4 Supply Canal to STA 3/4. S-623 is a four-bay gated spillway. The design flow is 3,700 cfs with a design hydraulic head of 0.25 feet. The design flow was established to match the existing capacity of the G-372 pump station downstream at 3,700 cfs. The spillway consists of four gates with dimensions of 35 ft wide by 14 ft high. The crest invert elevation is set to 3.50 ft NGVD. The upstream and downstream aprons are set at an elevation of -2.00 ft NGVD, with an apron length of 36 feet. S-623 is located in lin with the STA 3/4 upstream of the G-372 pump station. During PED, a Value Engineering investigation will be performed to optimize structure type and size for this design function.

Reference for Scope Basis:	Engineering Appendix dated March 2013 A.5.3.2.1.4 Water Control Structures A.5.3.2.1.4.2 Gated Spillway A.5.3.3.2.1.2 Table A-14.S-623 Gated Spillway A.5.4.3 Overflow spillways

Scope Assumptions:	- Assume similar to structure S-65EX. - Assume given dimensions in the engineering appendix govern over provided design documents for similar structu if no dimensions are given in the engineering appendix all dimensions will come from the similar structure. - The spillway will be built in a two phased construction only blocking half of the canal at a time. - Assume aprons are in addition to the concrete structure shown in the provided drawings. - Assume power for the structure will be provided from local power lines located .5 miles from the structure. - Assume that a diesel generator is needed for backup power. - Assume 50 ft deep sheet pile 880 ft long only 440 ft will be used, as it will be driven extracted and re-driven basec on the two phase construction. - Assume dewatering will be ongoing through feature of work. - Assume 50 KW Diesel Generator with 1000 gallon above ground tank.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

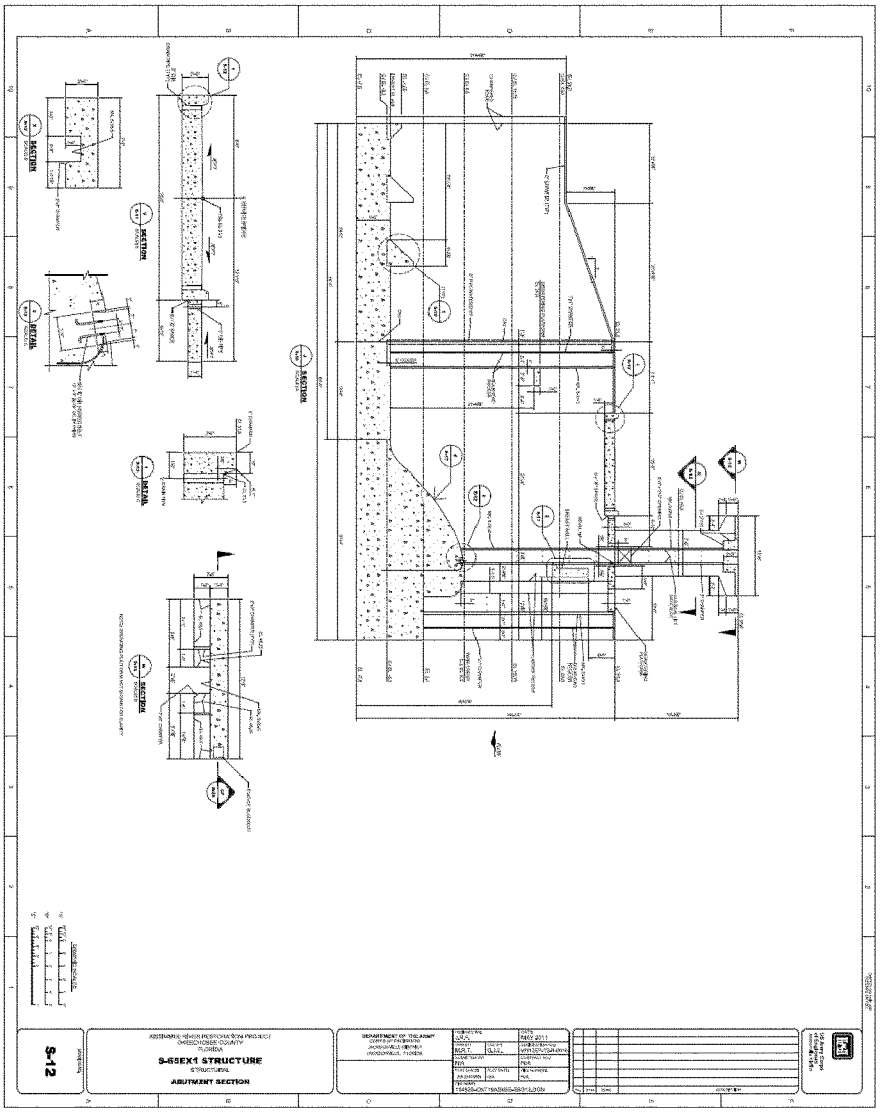
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope and assumptions were documented and sent to the design team for review. After reaching consensus on the scope and major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	Sheet pile half of the canal to allow for two staged construction of the gated spillway. Excavation of materials to allow for construction of the foundation of the cross canal gate structure and the canal apron/wingwall. Concrete work for structure followed by apron and wingwalls. Backfill suitable material around the structure and import riprap. Construct control station, diesel generator, and fuel storage. Place gates and other associated closure devices for the gate structure. Remove sheet pile and reinstall on opposite side and build second half of the spillw then restore flow to canal.

Key Outstanding Questions/Issues:	

Representative Drawings/Photos: S-623



Feature of Work: FEB - S-623 (DS-8) Gated Spillway 3700 CFS in 3/4 Canal

Quantity Take Off:

Structure Dimensions and volumes

Underwater Concrete Seal Volume (Unreinforced concrete)	=	9,481.5	CY	Assume underwater concrete is not reinforced, 10 ft thick 160 ft wide and 160 ft long			
Number of Gates	=	3.0	EA				
Superstructure/Gate Structure							
tower cross section	=	144.9	SF				
number of towers	=	4.0	EA				
pier cross section	=	154.1	SF				
number of Piers	=	2.0	EA				
tower width	=	3.5	FT				
Pier Height	=	35.0	FT				
beam cross section	=	15.0	SF				
Beam Length	=	69.0	FT				
volume	=	12,815.6	CF	=	474.7	CY	
volume of elevated beam	=	1,035.0	CF	=	38.3	CY	
Width	=	69.0	FT				
Cross section of platform,bridge,brestwall	=	46.5	SF				
Volume	=	3,211.3	CF	=	118.9	CY	
OGEE volume							
Cross section	=	143.9	SF				
width	=	69.0	FT				
OGEE Spillway volume	=	9,929.0	CF	=	367.7	CY	
Spillway wall volume (Abutment)	=	1,153.3	CY	Structure is 90' long and cross section of wall is 173 SF			
Approach apron	=	460.0	CY	Assumed 36ft long 89 ft wide and 5 ft thick per S-65EX design			
Stilling Basin	=	460.0	CY	Assumed 36ft long 89 ft wide and 5 ft thick per S-65EX design			

Wing Walls Assumed approach wing walls similar to downstream wing wall plan from S-65EX-1 with anchor walls. Construction will consist of driven sheet pile with a 2'x2' concrete pile cap. The anchor walls will be 1 ft thick reinforced concrete. Concrete anchor wall dimensions will match wing wall dimensions. The wing wall and concrete anchor wall will be connected by #10 all thread grade 70. A C8x18.75 channel will be attached to the back of the wing wall where the anchors will be attached to.

wing walls			
Number	=	4.0	Each
Length average US and DS	=	95.5	FT
US Depth	=	44.5	FT
DS Depth	=	26.5	FT

area of sheet pile	=	13,561.0	SF	=	183.1	TONS
Pile Cap						
height	=	2.0	FT			
width	=	2.0	FT			
volume	=	56.6	CY			
Anchor Rod length	=	60.0	FT			
spacing	=	4.0	FT			
number of rods	=	96.0	EA			
Anchor Walls						
height	=	8.0	FT			
thickness	=	1.0	FT			
length	=	382.0	FT			
volume	=	113.2	CY			
Rip Rap				Lengths and depths assumed to extend beyond aprons.		
Length	=	440.0	FT			
width	=	69.0	FT			
Depth	=	3.0	FT	average of all depths		
volume	=	3,373.3	ECY			
Excavation for Footing Volume	=	96,000.0	CF	Assume 89' wide (per width of channel) by 60 ft long (per S-65EX) and 10'		
	=	3,555.6	BCY	deep to allow for construction of the underwater seal and structural footings.		
	=	5,333.3	LCY			
Excavation east and west canal banks for installation of wing	=	177,600.0	CF	Assume top of bank is 15.5 ft NGVD (Per table A-14) and bottom of excavation		
	=	6,577.8	BCY	and bottom of excavation is at -23.5 ft NGVD (Total depth 37'). Assume		
	=	9,866.7	LCY	excavation is 160 ft long and extends the bottom of the canal an additional 15' per bank. Assume material is common or rippable as it is the bank of a levee.		
Sheet pile/cofferdam	=	880.0	LF	Assume 1200 LF of sheet pile/cofferdam to go around entire work site. Sheet		
	=	44,000.0	SF	pile will be driven 60ft deep. All sheet pile used as a coffer dam will be removed.		

Gate weight calculations

3/8" Plate steel	=	15.3	lb/sq ft				
1/2" Plate steel	=	20.4	lb/sq ft				
1" Plate Steel	=	40.8	lb/sq ft				
Gate Skin 3/8" Plate Steel	=	392.0	sq ft	Assume Gate dimensions of 14'x28'			
3/8" Plate stiffeners and seal angles	=	87.0	sq ft	Assume 5 sq ft for seal angles and 82 for stiffeners			
Horizontal C-Channels (1/2")	=	607.0	sq ft	Assume each channel is equivalent to 26"x28' (10 Channels).			
Vertical C-Channels (1/2")	=	303.0	sq ft	Assume each vertical channel is 26"x14' (10 Channels).			
Pull Pad eyes (1")	=	4.0	sq ft	Assume 4 pad eyes per gate @ 1 sq ft each			
Total 3/8" Plus 10% for misc. items	=	526.9	sq ft	=	8,061.6	lbs	
Total 1/2" plus 15% for misc items	=	1,046.5	sq ft	=	21,348.6	lbs	
Total 1" steel	=	4.0	sq ft	=	163.2	lbs	
lbs/sq ft for 28'x14' gate	=	75.4	lb/sq ft				
Area of single S-623 Gate	=	490.0	sq ft			assumed 3 ft bigger then opening in each direction	
Approximate weight of S-623 Gate	=	36,966.7	lb				
Overweight factor for larger gates (10%)	=	40,663.4	LB EA	=	20.3	Ton Each	3 needed.

Precast Concrete Control Building / Generator Shelter

Shelter square footage	=	315.0	sq ft	
Excavation/backfill for shelter	=	163.3	ECY	Building will be set on grade with 12" capillary water barrier and geotextile fabric and a 12" thick concrete curb around the building perimeter.
Generator Fuel Tank	=	1000 Gallon		
Fuel Pad dimensions	=	96.0	SF	Assume 8'x12'x12" thick reinforced concrete slab on grade pad.

Gate embeds/seal lengths

Gate Dimensions				
Width	=	35.0	FT	
Height	=	14.0	FT	
Gate well Height	=	42.0	FT	
Gate Well Embed	=	119.0	FT	
Total Embed length	=	357.0	FT	3 gates
Seal Length	=	63.0	FT	seal length is the perimeter of bottom and both sides.
Total Seal length	=	189.0	FT	total of 3 gates
Up and Downstream Bulkhead Slot	=	588.0	FT	6 times vertical plus width of new gate per slot
Bulkheads	=	40,663.4	LB EA	assume same size as gates
number	=	6.0	EA	two per gate needed
Total Length of imbeds	=	945.0	FT	
Total Weight of gates and stoplogs	=	365,970.5	LB	= 183.0 TON
TOTAL J BULB for GATES AND STOP LOGS	=	567.0	FT	

Backfill

Structure Backfill	=	3,555.6	ECY	=	4,017.8	LCY

Railings and ladders

Railing				
Length	=	958.0	FT	assumed 4 time the length of a wing wall and 6 times the width of the
Height	=	3.5	FT	structure and twice the length
Ladders				
Count	=	6.0	EA	assumed ladders on each side of the structure.
Height	=	17.5	FT	average of all three types
total height	=	105.0	FT	

Boat Barrier

Number	=	2.0	EA	
Length each	=	140.0	FT	assumed
Total Length	=	280.0	FT	

Site Fencing

Length	=	1,000.0	FT	assumed a total of 1000 LF of chain link fencing.
Gates	=	4.0	EA	assumed

Access road

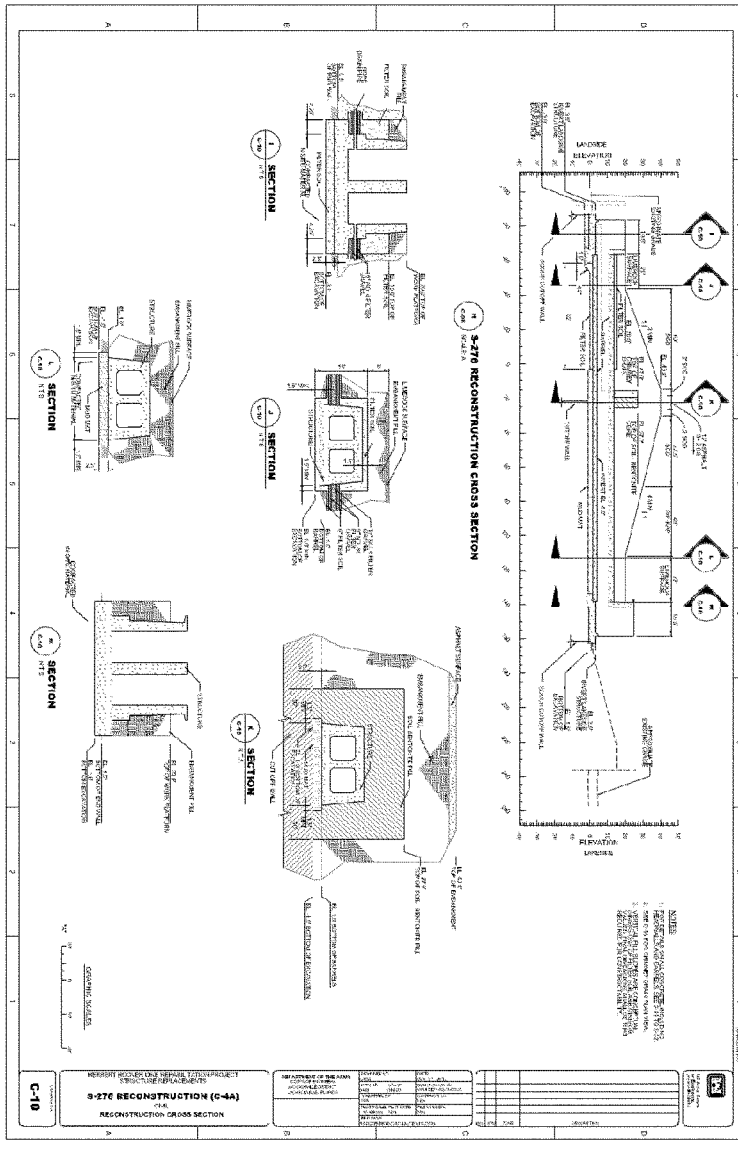
Length	=	300.0	FT		assumed	
Width	=	14.0	FT		assumed	
Area	=	4,200.0	SF	=	466.7	SY

SWPPP

Length	=	1,500.0	LF	
Floating Silt Boom	=	250.0	LF	assumed

Feature of Work:	FEB - S-624 (DS-5) Gated Sag Culvert (FEB Inflow Structure) 1550 CFS from STA 3/4 Supply canal.
Scope Given:	The S-624 structure is a gated sag culvert that serves as the controlled inflow into the A-2 FEB. This structure will operate in conjunction with the existing G-372 pump station to route flows from the Miami Canal into the impoundment when storage capacity is available. The structure will open for inflow operations into the FEB from G 372, and will close during A-2 FEB by-pass operations (flow directly to STA 3/4 or the A-1 FEB) or to prevent back fl into STA 3/4 Supply Canal. S-624 is a two-barreled, gated sag culvert with four 45 degree bends. The culverts will r from the STA 3/4 Supply canal, beneath the FEB discharge/collection canal, and into the FEB inflow canal/flow way The design flow is 1,550 cfs with a design hydraulic head of 2.5 feet resulting in a design velocity of 6.75 fps. This velocity was targeted in design to provide a scour velocity to clean out culverts, thereby reducing periodic maintenance requirements. The structure is a two barreled cast-in-place concrete box culvert with dimensions of 1 ft by 11 ft each with vertical slide gates, and a total length of approximately 350 ft. The upstream invert is set at elevation -4.50 ft NGVD, 0.5 feet above the existing bottom elevation of the STA 3/4 Supply Canal. The downstrean invert is set at elevation 0.50 ft NGVD, 0.5 feet above the proposed bottom elevation of the FEB Inflow Canal. The S 624 structure is designed to cross beneath the existing collection canal (invert elev. 0.00 ft NGVD) with a spacing of feet, resulting in a minimum barrel sag invert of -14.00 ft NGVD. S-624 is located near the southwest corner of the 2 FEB, east of the G-372 pump station.
Reference for Scope Basis:	Engineering Appendix dated March 2013 A.5.3.2.1.4 Water Control Structure A.5.3.3.2.1.1 Gated Culverts Table A-15. S-624 Gated Culvert A.5.4.4
Scope Assumptions:	- Assume similar to structures S-276 and S-277 but will be a SAG culvert. - Assume given dimensions in the engineering appendix govern over provided design documents for similar structu if no dimensions are given in the engineering appendix all dimensions will come from the similar structure. - Assume sheet pile will need to be driven around inlet structure on the canal side. Sheet pile depth 50 ft, set back from excavation of 25 ft, with pumping ongoing during construction in conjunction with a rim ditch excavation around the remainder of the sag culvert excavation. -Assume Excavation will be to the same depth below finished grade as shown in contract drawings for similar projects with a slope of 1:2 for construction. - Assume material as 1.5 ft of organic, 10 ft of blastable cap rock, and inter-bedded formation of sand/shell and fragmented limestone for the remainder of the excavation. - Assume power will be provided from power lines in the area approximately 500'. - Assume that a diesel generator is needed for backup power.
Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.
Sequence of Work:	-Assume sheet piling will be utilized around the perimeter of the excavation/project site and dewatering will be required. Sheet pile will be installed around the inlet structure. A rim ditch water system will be utilized to dewater the excavation around which the culver will be constructed. Upon completion of the concrete work backfill and compact excavation as required for other features of work (L-624 Levee, L-625 Levee and C-625 canal). Gated structures power will be sourced from local power and installed to the control station. A backup generator will be required along with a fuel pad.
Key Outstanding Questions/Issues:	

Representative Drawings/Photos: S-624



Feature of Work: FEB - S-624 (DS-5) Gated Sag Culvert (FEB inflow Structure) 1550 CFS from STA 3/4 Sup

Quantity Take Off:

Sheet Pile

Width	=	266.0	FT		assumed 25 ft from nearest excavation					
Length	=	200.0	FT		Assumed 100 ft back from canal					
Depth	=	50.0	FT							
Area	=	46,600.0	SF							

Levee Removal

Length	=	266.0	FT		Assumed same as width of sheetpile					
Height	=	14.0	FT		Assumed levee dimensions					
Top Width	=	14.0	FT		Assumed levee dimensions					
Side Slope	=	3.0	:1							
Bottom Width	=	98.0								
Volume	=	208,544.0	CF	=	7,723.9	BCY	=	9,654.8	LCY	

Rim Ditch Excavation

Length	=	390.0		ft	Length of excavation					
Width	=	112.0		ft	Bottom width of excavation					
Canal Dimension	=	3ft deep x 3 ft wide								
Ditch volume	=	4,518.0	CF	=	167.3	BCY	=	209.2	LCY	

Sag culvert excavation

Length	=	390.0	FT		0.1	Miles =	390.0			
Total Depth	=	26.0	FT							
Thickness of Organic	=	1.5	FT							
Thickness of Blasting Cap Rock	=	10.0	FT							
Thickness inter-bedded material	=	14.5	FT							
Slope1	=	2.0	:1							
Slope2	=	2.0	:1							
Bottom Width	=	112.0	FT							
Top Width	=	216.0	FT							
Cross Section	=	4,264.0	SF							
Cross Section Organic	=	319.5	SF							
Cross Section of Blasting Cap Rock	=	1,900.0	SF							
Cross section Inter-Bedded Material	=	2,044.5	SF							
Surface Area of Canal	=	84,240.0	SF	=	1.9	ACRE				
Organic Volume	=	124,605.0	CF	=	4,615.0	BCY	=	5,768.8	LCY	
Blasted Cap Rock Volume	=	741,000.0	CF	=	27,444.4	BCY	=	34,305.6	LCY	
Inter-bedded Material Volume	=	797,355.0	CF	=	29,531.7	BCY	=	44,297.5	LCY	
		TOTAL		=	61,591.1	BCY				

Concrete Culvert Concrete

Length	=	350.0	FT							
Foundation Concrete										
Bottom Width	=	32.0	FT							
Bottom Thickness	=	2.5	FT							
Volume	=	28,000.0	CF	=	1,037.0	CY				
Vertical concrete										
Height	=	11.0	FT							
width of walls	=	8.8	FT							
Volume	=	33,687.5	CF	=	1,247.7	CY				
Elevated Concrete										
Top Width	=	29.6	FT							
Thickness	=	2.5	FT							
Volume	=	25,900.0	CF	=	959.3	CY				
PVC water stops	=	2.0	EA							
Length	=	93.5	LF							
Spacing	=	15.0	FT							
Total Length	=	4,488.0	LF							

Inlet and Outlet Works

Number	=	8.0	EA		assumed intake and outlet are the same assumed 2 per each end gate and bulkhead					
Foundation										
Length	=	8.0	FT							
Depth	=	5.0	FT							
Width	=	47.0	FT							
Volume	=	7,520.0	CF	=	278.5	CY				
Head Walls										
Height	=	25.5	FT							
Thickness	=	3.0	FT							
width	=	35.0	FT							
openings	=	242.0	SF							
volume	=	7,806.0	CF	=	289.1	CY				
End walls										
height	=	24.0	FT							
length	=	100.0	FT		total each side					
thickness	=	2.0	FT							
volume	=	9,600.0	CF	=	355.6	CY				

MISC METALS

Railing	=	358.0	LF							
Ladders	=	4.0	EACH							
height	=	25.5	FT EA	=	102.0	FT TOTAL				
Grating	=	400.0	SF per Gate				assumed 20 by 20 section of grating per gate per end.			
TOTAL Grating	=	1,600.0	SF							

Gates IN HHD

Height	=	14.0	FT		*** STAINLESS STEEL					
Width	=	10.0	FT							
Weight	=	6,500.0	LB							
Weight Per SF	=	46.4	LB/SF							

NEW GATES

number of gates	=	8.0	EA		assumed 2 on each end 1 gate and one bulkhead.					
Height	=	18.0	FT		assumed 4 ft larger then similar gate					
Width	=	14.0	FT		assumed 4 ft larger then similar gate					
Weight % larger	=	10.0	%		assumed					
Total Weight of gates	=	12,870.0	LB EA	=	102,960.0	LB total	=	51.5	TON	
Motors	=	8.0	EA							
Gear Reduction	=	8.0	EA							
Actuators	=	8.0	EA							
cable reels	=	8.0	EA							
Imbeds for gate	=	520.0	LF							
Gate Seal Length	=	512.0	LF							

Operations building

size	=	315.0	SF		21 x 15					
Electrical	=	NEEDED								
Communications	=	NEEDED								

Backfill

Existing Levees	=	208,544.0	CF	=	7,723.9	ECY	=	8,728.0	LCY	
Area of Levee	=	26,068.0	SF	=	2,896.4	SY				
Area above Culvert	=	1,662,960.0	CF	=	61,591.1	ECY	=	69,598.0	LCY	

Cut off walls

	Number	=	2.0	EA			assumed one in the STA3/4 Levee and one in the FEB perimeter Levee.
	Soil Bentonite Fill						
	Height	=	25.0	FT			
	Width	=	52.0	FT			
	Thickness	=	8.0	FT			
	Volume	=	10,400.0	CF/EA	=	385.2	CY/EA
	TOTAL VOLUME	=	770.4	CY			
	Cutoff Wall						
	Depth	=	35.0	FT			
	Width	=	112.0	FT			
	Thickness	=	3.0	FT			
	Volume	=	11,760.0	CF/EA	=	435.6	CY/EA
	Area	=	3,920.0	SF/EA			
	TOTAL AREA	=	7,840.0	SF			

RIP RAP

	common both sides						
	number of placements	=	2.0	EA		1 each side	
	Length	=	20.0	FT			
	Width	=	47.0	FT			
	thickness	=	4.0	FT			
	Volume	=	3,760.0	CF EA	=	139.3	ECY EA
	Total Volume	=	278.5	ECY	=	445.6	TON

Boat Barrier

Number	=	3.0	EA		
Length	=	98.0	FT		
Total Length	=	294.0	FT		

SWPPP

Floating Silt Boom	=	980.0	FT		assumed 10 times the width of the canal.
Silt Fence	=	6,492.0	FT		

Site Fence

Length	=	1,000.0	FT		Assumed
gates	=	4.0	FT		assumed

Feature of Work:	FEB - S-625 (DS-7) Gated Culverts (FEB Discharge Structure) From Collection Canal to Outflow Canal 1550 CFS

Scope Given:	S-625 conveys flows from the A-2 FEB to the G-372 pump station via a new discharge canal (C-625W) from the FEB 625 will only pump into G-372 if flow from the Miami Canal is blocked via use of S-623 gated spillway. Consisting of each 9 ft by 9 ft box culvert with an overall culvert length of 140 ft.

Reference for Scope Basis:	Engineering Appendix dated March 2013 A.5.3.2.1.4 Water Control Structure A.5.3.3.2.1.1 Gated Culverts Table A-16. S-625 Gate Culvert

Scope Assumptions:	- Assume similar to structures S-276 and S-277. - Assume given dimensions in the engineering appendix govern over provided design documents for similar structu if no dimensions are given in the engineering appendix all dimensions will come from the similar structure. - Pumping ongoing during construction in conjunction with a rim ditch excavation around the Structure. -Assume Excavation will be to the same depth below finished grade as shown in contract drawings for similar projects. - Assume material as 1.5 ft of organic, 10 ft of blastable cap rock, and inter-bedded formation of sand/shell and fragmented limestone for the remainder of the excavation. - Assume power will be provided from power lines in the area approximately 1000'. - Assume that a diesel generator is needed for backup power.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

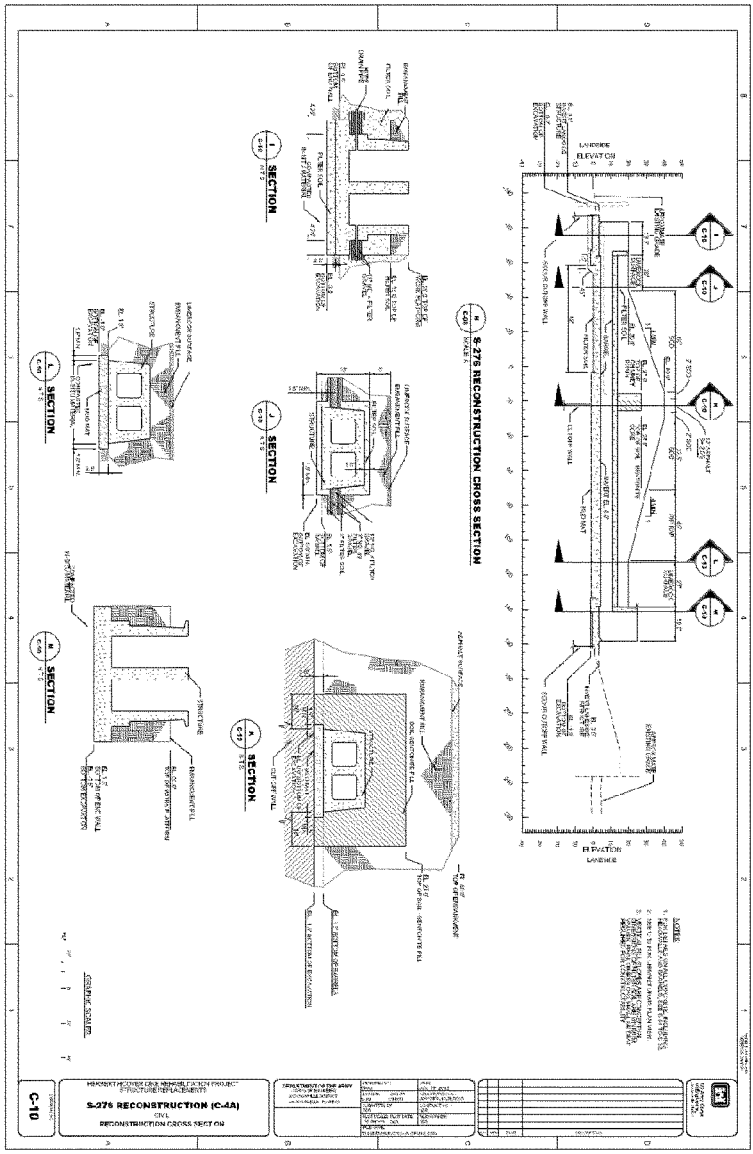
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope and assumptions were documented and sent to the design team for review. After reaching consensus on the scope and major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	-Upstream canal depth 0' NGVD and 45' wide, Downstream canal depth -5' NGVD 45' wide. Construction will be performed prior to excavation for the C-625E and C-625W canals. Dewatering will be needed, utilizing rim ditch and dewatering pumps used as needed. Excavation/blasting of limestone rock will be required to allow space for the foundation for the drainage structure. Culverts, foundations and structures will then be placed. Control structures for the culverts will be installed and assume that the control station for the SAG Culvert will also have control of th discharge structure. An additional backup generator will be required along with local utility power. The shelter for the generator will be placed on the west side of the FEB perimeter levee. Apron, wing wall, and riprap placement will occur after culverts have been placed. Backfill and compaction around the structure will occur, and then the F perimeter levee (L-624) will be built on top of the culverts.

Key Outstanding Questions/Issues:	

Representative Drawings/Photos: S-625



Feature of Work:	FEB - S-625 (DS-7) Gated Culverts (FEB Discharge Structure) From Collection Canal to Outflow Canal 1550 CFS

Quantity Take Off:

Rim Ditch Excavation

Length	=	200.0	ft	Length of excavation						
Width	=	119.0	ft	Bottom width of excavation						
Canal Dimension	=	3ft deep x 3 ft wide								
Ditch volume	=	2,871.0	CF	=	106.3	BCY	=	132.9	LCY	

Culvert excavation

Length	=	200.0	FT							
Total Depth	=	11.0	FT							
Thickness of Organic	=	1.5	FT							
Thickness of Blasting Cap Rock	=	9.5	FT							
Slope1	=	2.0	:1							
Slope2	=	2.0	:1							
Bottom Width	=	119.0	FT							
Top Width	=	163.0	FT							
Cross Section	=	1,551.0	SF							
Cross Section Organic	=	240.0	SF							
Cross Section of Blasting Cap Rock	=	1,311.0	SF							
Surface Area of Canal	=	32,600.0	SF	=	0.7	ACRE				
Organic Volume	=	48,000.0	CF	=	1,777.8	BCY	=	2,222.2	LCY	
Blasted Cap Rock Volume	=	262,200.0	CF	=	9,711.1	BCY	=	14,566.7	LCY	
		TOTAL		=	11,488.9	BCY				

Concrete Culvert Concrete

Length	=	160.0	FT							
Foundation Concrete										
Bottom Width	=	39.0	FT							
Bottom Thickness	=	2.5	FT							
Volume	=	15,600.0	CF	=	577.8	CY				
Vertical concrete										
Height	=	9.0	FT							
width of walls	=	12.5	FT							
Volume	=	18,000.0	CF	=	666.7	CY				
Elevated Concrete										
Top Width	=	34.5	FT							
Thickness	=	2.5	FT							
Volume	=	13,800.0	CF	=	511.1	CY				
PVC water stops	=	2.0	EA							
Length	=	87.5	LF							
Spacing	=	15.0	FT							
Total Length	=	1,925.0	LF							

Inlet and Outlet Works

Number	=	12.0	EA	assumed intake/outlet are the same assumed 2 per each end gate and bulkhead						
Foundation										
Length	=	8.0	FT							
Depth	=	5.0	FT							
Width	=	57.0	FT							
Volume	=	9,120.0	CF	=	337.8	CY				
Head Walls										
Height	=	25.5	FT							
Thickness	=	3.0	FT							
width	=	45.5	FT							
openings	=	243.0	SF							
volume	=	11,007.0	CF	=	407.7	CY				
End walls										
height	=	24.0	FT							
length	=	100.0	FT	total either inlet or outlet						
thickness	=	2.0	FT							
volume	=	9,600.0	CF	=	355.6	CY				

MISC METALS

Railing	=	358.0	LF						
Ladders	=	6.0	EACH						
height	=	25.5	FT EA	=	153.0	FT Total			
Grating	=	400.0	SF per Gate			assumed 20 by 20 section of grating per gate per end.			
TOTAL Grating	=	2,400.0	SF						

Gates IN HHD

Height	=	14.0	FT	*** STAINLESS STEEL for opening 7 by 7					
Width	=	10.0	FT						
Weight	=	6,500.0	LB						
Weight Per SF	=	46.4	LB/SF						

NEW GATES

number of gates	=	12.0	EA	assumed 2 on each end 1 gate and one bulkhead.					
Height	=	16.0	FT	assumed 2 ft larger then similar gate					
Width	=	12.0	FT	assumed 2 ft larger then similar gate					
Weight % larger	=	10.0	%	assumed					
Total Weight of gates	=	9,805.7	LB EA	=	117,668.6	LB	=	58.8	TON
Motors	=	12.0	EA						
Gear Reduction	=	12.0	EA						
Actuators	=	12.0	EA						
cable reels	=	12.0	EA						
Imbeds for gate	=	756.0	LF						
Gate Seal Length	=	672.0	LF						

Operations building

size	=	315.0	SF	21 x 15					
Electrical	=	NEEDED							
Communications	=	NEEDED							

Backfill

Area above Culvert	=	310,200.0	CF	=	11,488.9	ECY	=	12,982.4	LCY

Cut off walls

Number	=	1.0	EA	Assumed in FEB perimeter Levee					
Soil Bentonite Fill									
Height	=	25.0	FT						
Width	=	59.0	FT						
Thickness	=	8.0	FT						
Volume	=	11,800.0	CF/EA	=	437.0	CY			
Cutoff Wall									
Height	=	35.0	FT						
Width	=	119.0	FT						
Thickness	=	3.0	FT						
Volume	=	12,495.0	CF	=	462.8	CY			
Area	=	4,165.0	SF						

RIP RAP

common both sides									
number of placements	=	2.0	EA	1 each side					
Length	=	20.0	FT						
Width	=	57.0	FT						
thickness	=	4.0	FT						
Volume	=	4,560.0	CF/EA	=	168.9	CY/EA			
Total Volume	=	337.8	ECY	=	540.4	TON			

Boat Barrier

Number	=	2.0	EA						
Length	=	163.0	FT						
Total Length	=	326.0	FT						

SWPPP

Silt Fence	=	966 ft	FT						

Site Fence

Length	=	1,000.0	FT	Assumed					
gates	=	4.0	FT	assumed					

Feature of Work:	FEB - S-626 (PS-1) Seepage Pump Station, 500 CFS

Scope Given:	The CEPP Recommended Plan proposes to construct a new seepage collection pump station, S-626, for seepage management. The pumping rate of 500 cfs was established to accommodate the peak estimated seepage inflow ra of 400 cfs, as well as provide additional capacity for possible high flow events. The s-626 pump station will return seepage intercepted in the FEB seepage canal back to the existing G-372 pump station through the C625W Outflow canal. Pumps will be (3) 100 CFS Electric pumps with (1) 200 CFS Diesel engine pump that will also serve as a backu generator.

Reference for Scope Basis:	Engineering Appendix dated March 2013 A.5.3.2.1.4 Water Control Structures A.5.3.2.1.4.4 Pump Stations A.5.3.3.2.1.4 Pump Stations Table A-18. S-626 Pump Station A.5.5.3 Pumping Station S-626

Scope Assumptions:	Scope Assumptions: - Assume similar to structure Pump Station 357. - Assume given dimensions in the engineering appendix govern over provided design documents for similar structu if no dimensions are given in the engineering appendix all dimensions will come from the similar structure. - Assun there will be a total of 4 pumps, three 100 cfs electric pumps and one 200 cfs diesel engine driven pumps. - Assume discharge of pumps will be piped by three 3' diameter steel pipe and will terminate in a discharge structu built into C-625W for the 100 CFS pumps and one 4' diameter pipe for the diesel driven pump. - Assume the discharge structure will consist of a concrete headwall full height of the canal 30 ft wide 18 inch thick reinforced concrete, 20'x30' apron 18 inch thick reinforced concrete, wing walls extending 30ft up and downstrean of the discharge point sloping from full height of the canal to 0 18 inch thick reinforced concrete and riprap lining 1 ft beyond the concrete apron. - Assume the excavation will extend 3 feet below the seepage canal bottom elevation. - Assume material as 1.5 ft of organic, 10 ft of blastable cap rock, and inter-bedded formation of sand/shell and fragmented limestone for the remainder of the excavation. - Assume excavation for the pump station is separate in scope from the excavation of the seepage canal or the C-625W canal. - Assume pump station will be constructed of reinforced concrete below grade and a Combination of cast-in-place columns and reinforced CMU walls. . - Assume a fuel pad will be required for storage tanks for the diesel pump and the diesel generator, assumed size o 20' by 20' 2 feet thick reinforced concrete. - Assume discharge will be directed into the C-625W by the discharge piping directed downstream.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

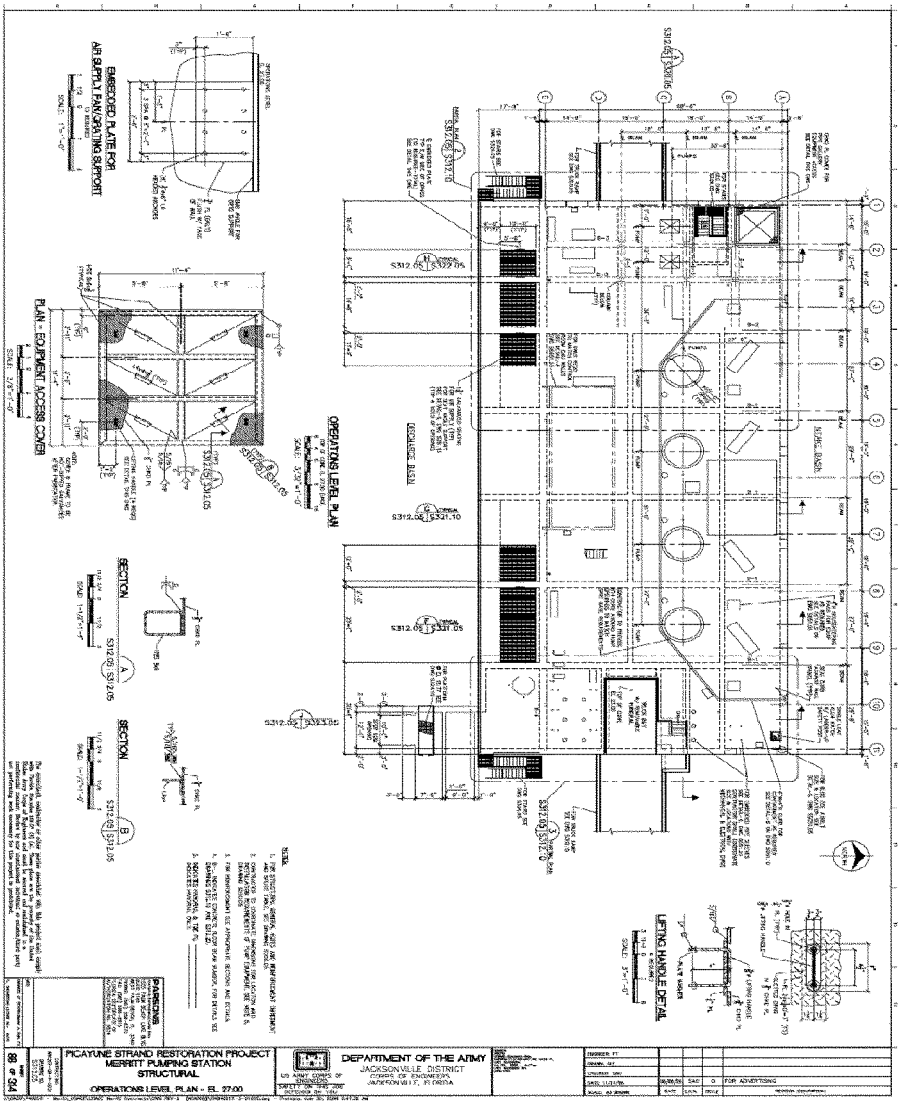
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	Pump Station will be installed at the end of C-626 seepage canal. Excavation will be required to provide suitable foundation for the pump station. Excavation of the pump station will be completed prior to excavation of the seepage canal or out flow canal thus minimal dewatering will be required. The pump station will be constructed on site. The pump station will also have a 480 volt, 3 phase, diesel generator. The station will have housing accommodations including bed, shower, water closet, HVAC, potable water, sanitary sewer and communications equipment (radio transmitter).

Key Outstanding Questions/Issues:	

Representative Drawings/Photos: S-626



Feature of Work:	FEB - S-678 (PS-1) Seepage Pump Station, 500 CFS

Quantity Take Off:

Rim Ditch Excavation

Length	=	60.0	ft	Length of excavation						
Width	=	80.0	ft	Bottom width of excavation						
Canal Dimension	=	3ft deep x 3 ft wide								
Ditch volume	=	1,260.0	CF	=	46.7	BCY	=	58.3	LCY	

FEB Seepage Pump Station Excavation.

Length	=	60.0	FT	Assume 60 ft to allow for footprint of pump station						
Total Depth	=	21.5	FT	Assume Channel depth is 14.5' with an additional 7' of over excavation for structure.						
Thickness of Organic	=	4.5	FT							
Thickness of Blasting Cap Rock	=	10.0	FT							
Thickness inter-bedded material	=	7.0	FT							
Slope1	=	-	:1							
Slope2	=	-	:1							
Bottom Width	=	80.0	FT	Assume 90 ft to allow for footprint of Pump Station						
Top Width	=	80.0	FT							
Cross Section	=	1,720.0	SF							
Cross Section Organic	=	360.0	SF							
Cross Section of Blasting Cap Rock	=	800.0	SF							
Cross section Inter-Bedded Material	=	560.0	SF							
Surface Area of Canal	=	4,800.0	SF	=	0.1	ACRE				
Organic Volume	=	21,600.0	CF	=	800.0	BCY	=	1,000.0	LCY	
Blasted Cap Rock Volume	=	48,000.0	CF	=	1,777.8	BCY	=	2,666.7	LCY	
Inter-bedded material Volume	=	33,600.0	CF	=	1,244.4	BCY	=	1,866.7	LCY	
Backfill	=	10,320.0	CF	=	382.2	ECY	=	553.3	LCY	
Assume Backfill is 10% of excavated quantity.										

Care and Diversion of Water

Construction Sequence:

1 Construct perimeter concrete ring beam and rock anchors.
2 Place Sheet piling and connect piling to concrete ring beam. Excavate. Assume sheet pile length of 36 ft
3 Install rock anchors for concrete seal slab. Anchor length 17'-6" slab rock anchor.
4 Place Concrete Seal slab. 6'-0" thick and dimensions of sheet pile
5 Dewater cofferdam and prepare top of concrete base mat slab
6 Place concrete walls to elevation 9'-0" at pump structure monolith prior to abandoning or removing in place cofferdam sheet piles. Remove ring beams in inlet and outlet.
7 Install lateral bracing for walls.
8 Construct service bridge slab. Remainder of walls and operating floor slab.
9 Install sheet pile wing walls.

# of pump station Bays	=	4.0		
Cofferdam width per pump station bay	=	15.0	ft	Assume Per S-101
Total width length	=	60.0	ft	
Length (Up and downstream) of Cofferdam	=	90.0	ft	Assume per S-101
Area of Cofferdam sheet pile to remain in place	=	9,000.0	SF	

Total perimeter length (length of sheet pile/ring beam)	=	300.0	ft	
Length of Sheet pile to Be utilized as wing wall	=	186.0	ft	
Volume of ring beam (Reinforced Concrete	=	70.4	CY	Per detail S-103
# of 54' ring beam anchors @ 10' OC	=	30	ea	Per detail S-101
# of 17'-6" uplift slab rock anchors	=	54	ea	
Volume of Concrete seal/uplift slab	=	1,200.0	CY	Assume 6' thick
Width of each Bay	=	15.00	ft	Assumed per similar PS-357
Length of Operating Floor	=	45.0	ft	
Width of Operating Floor	=	60.0	ft	

Horizontal concrete volume	=	800.0	CY				
Vertical Concrete	=	1,500.0	CY				
Service Bridge Elevated Flatwork	=	190.1	CY	Total Elevated Flatwork	=	446.4	CY
Operating Floor (Elevated Flatwork	=	225.0	CY				
Elevated Vertical Work (Operating floor to	=	31.3	CY				
Roof slab / Metal Deck	=	220.0	CY				
Loading Truck Ramp (horizontal Concrete)	=	4,903.0	SF	=	272.4	CY	Assumed From Merritt Pump Station
SF of Generator, Electric and Office/Contro	=	900.0	SF	Assume Generator room. Electric Room and Office control room is 20ftx39ft			
Volume of Concrete for Gen, Elec and Offic	=	1,500.0	CF	=	55.6	CY	Assume 1.67 ft thick
Assume 10 18"x18"x26' tall Columns	=	21.7	CY				
Tilt Up 7-1/2" Thick Precast Panels	=	21,072.0	SF	Assume Similar to Merritt Pump Station			
CMU Wall Dimensions (Exterior Surface Area of CMU)	=	7,044.0	SF				
Roof 32" Double tee units 56 ft long required	=	8	each				
Intake Basin Concrete	=	89	CY				
Discharge Basin Concrete Apron	=	133.3	CY	Assume 36" thick concrete			
Stone Protection Riprap discharge	=	1,688.9	CY	Assume 5 ft thick layer of riprap lining the C-625W canal upstream 60 ft and downstream 60 ft.			
Stone Protection inlet	=	750.0	CY	Assume 36" thick layer of riprap lining the sides and bottom for 150' upstream			
Trash Rack Surface Area (total)	=	1,680.0	SF	Assume Trash rake is 28 ft tall and covers the width of the operating floor each individual covers the width of the bays (14ft).			
Roll Up Garage Door	=	168.0	SF	Assume Roll up garage door 12'x14'			
# of Doors	=	4.0	ea	Assume 1 set of double doors and two other doors			
# louver openings	=	8.0	ea	Assume 8 louver openings 7'-4" square			
Overhead Crane	=	2.0	ea	Assume 2 overhead cranes @ 25 tons each			
Power Line Connection	=	2,500.0	LF	Assume power available 2500 lf from site			
Septic tank system	=	1.0	ea	Assume 1 septic tank system			
Potable water	=	1.0	ea	Assume 1 potable water well will be required			
Generator Fuel Tank	=	2000 Gallon	ea	Assume two 2000 gallon fuel tanks required			
Fuel Pad dimensions	=	400.0	SF	Assume two 20'x20'x2' thick reinforced concrete slab on grade pad.			
		44.4	CY				
Discharge Piping							
48" discharge pipe	=	50.0	LF/ea	Assume Pumps will have a 48" Discharge Piping			
Concrete Encasement	=	349.1	CY	Assume 2 ft of concrete to encase piping			
Floor Grating	=	240.0	SF	Assume 14' x4 ft wide for each pump bay.			
Ladders	=	120.0	VLF	Assume 30 ft per pump bay			
Railings	=	180.0	LF	Assume a handrail on the up and downstream side and one a width of the operating floor			
Haul road length	=	21,120.0	FT				
Haul road width	=	14.0					
Haul road thickness	=	1.0	FT				
Area	=	295,680.0		SF =	32,853.3		see
Chain link Fence	=	2,280.0	LF	Assume Similar to Merritt Pump Station			
Silt Fence	=	3,700.0	LF	Assume similar to Merritt Pump Station			

Feature of Work:	FEB - S-627 (CS-4) Emergency Overflow Weir 445/1850 CFS Between A-2 and A-1 FEB, just north of S-628

Scope Given:	The spillway will include a 265 foot long weir with crest elevation set at 13.50 ft NGVD. The spillway will discharge into the adjacent seepage canal along the northern portions of the A-1 and A-2 FEBs. The spillway will be located in line with the northern extent of the eastern perimeter levee, adjacent to structure S-628. S-627 is an overflow weir that will have the same crest width as the levee of 14 feet. The design will be similar to the overflow weir design in the C-111 South Dade S-327.

Reference for Scope Basis:	Engineering Appendix dated March 2013 A.5.4.5 Weirs A.5.3.3.2.1.5 Other Features

Scope Assumptions:	- Assume similar to structure S-327. - Assume given dimensions in the engineering appendix govern over provided design documents for similar structu if no dimensions are given in the engineering appendix all dimensions will come from the similar structure. - FEB is not operational prior to overflow weir being constructed. - Assumed that levee is constructed to design grade of overflow weir. Minimal excavation is needed prior to placement of concrete. - Assumed that the weir will start at the toe of the levee then rise at a constant slope up to elevation 13.5 ft be 14 l wide then back down to the opposite toe of the levee.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

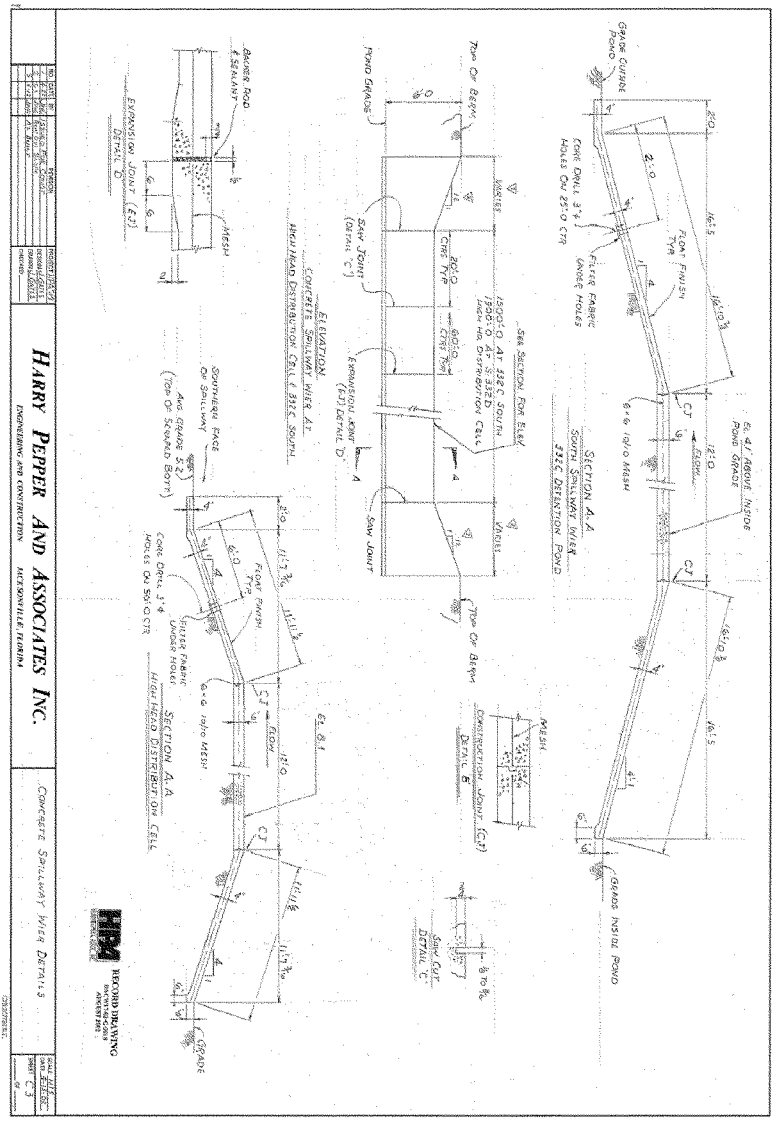
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope and assumptions were documented and sent to the design team for review. After reaching consensus on the scope and major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	- Site survey and stake entire area of Emergency Overflow Weir. - Silt Fence the entire site. Silt fence maintenance will be ongoing during construction of the overflow weir. - Excavate site for keyed ends near the toe of the levee and the intersection of the levee crown and the weir. - Place filter fabric below future holes, set and tie reinforcing. Form, place, finish, and cure concrete. Saw cut joints Strip forms backfill and compact at edges of concrete.

Key Outstanding Questions/Issues:	

Representative Drawings/Photos: S-627



Feature of Work:	FEB - S-627 (CS-4) Emergency Overflow Weir 445/1850 CFS Between A-2 and A-1 FEB, just north of S-628

Quantity Take Off:

Excavation

Length of spillway	=	265.0	FT						
Width of spillway	=	14.0	FT						
elevation of levee	=	20.3	FT						
elevation of spillway	=	13.5	FT						
base width of levee	=	82.0	FT						
Base elevation of levee	=	9.0	FT						
Slope length of spillway	=	34.3	FT						
Slope towards levee from Spillway Crest	=	12.0	:1						
each side length of slope	=	81.9	FT						
Apron length	=	2.0	FT						
Depth	=	1.0	FT	assumed depth					
backfilled material	=	15.0	%	assumed					
TOTAL Volume	=	36,080.2	CF	=	1,336.3	BCY	=	1,670.4	LCY

Concrete

Top of levee depth	=	0.5	FT						
Slopes of levee depth	=	0.3	FT						
volume	=	10,282.4	CF	=	380.8	CY			
area	=	27,845.7	SF						
total length of spillway concrete	=	428.8	FT						
total length over spillway	=	82.6	FT						
saw cut spacing	=	20.0	FT						
number of saw cuts	=	21.0	EA						
length of saw cut	=	1,734.5	LF						
Spacing of expansion joints	=	60.0	FT						
number of Expansion joints	=	7.0	EA						
Length of Expansion joints	=	578.2	FT						

Backfill

Volume	=	200.4	ECY	=	226.5	LCY			

Site Prep

Area of work	=	34,807.1	SF	=	0.8	Acre			
Length of Silt Fence	=	1,278.4	LF						

Silt Fence

Floating Silt Boom	=	428.8	LF	
Silt Fence	=	1,276.9	LF	assumed 125% longer then the perimeter of the work area

Feature of Work:	FEB - S-628 (DS-9) Gate Culvert FEB Intake / Discharge structure between A-1 and A-2 FEB 930 CFS

Scope Given:	S-628 is a bi-directional inlet and outlet structure that hydraulically connects the A-2 FEB to the A-1 FEB. This featu will allow water to be passed between the A-2 and A-1 FEBs, depending on impoundment stages and capacity. Wat from the Miami Canal could potentially be routed through the A-1 FEB by use of this structure. The opposite operation can occur, using water routed through A-1 from the North New River Canal via G-370 pump station and (15 to supplement water in A-2. S-628 is a two-barreled gated box culvert with dimensions of 9 ft by 9 ft with vertic slide gates. The design flow is 930 cfs (60% of total A-2 inflow, assuming only partial flow would be conveyed between impoundments) with a design hydraulic head of 1.0 foot. The upstream and downstream barrel inverts ar set at elevation 1.50 ft NGVD. The design velocity through the structure is 5.75 fps. S-628 is located in the northeas corner of the A-2 FEB, in line with the eastern levee shared by A-1 and A-2.

Reference for Scope Basis:	Engineering Appendix dated March 2013 A.5.3.2.1.4 Water Control Structures A.5.3.3.2.1.1 Gated Culverts Table A-17.S-628 Gated Culvert

Scope Assumptions:	- Assume similar to structures S-276 and S-277. - Assume given dimensions in the engineering appendix govern over provided design documents for similar structu if no dimensions are given in the engineering appendix all dimensions will come from the similar structure. - Assume S-628 is built prior to construction of the L-624 but after the A-1 FEB is operational. - Assume sheet pile will need to be driven around the A-1 side intake/discharge structure. Sheet pile depth 50 ft, se back from excavation of 25 ft, with a rim ditch in conjunction with pumping ongoing during construction. - Assume the Seepage canal between the A-1 FEB and the A-2 FEB is operational and will need plugs up and downstream of the culvert. -Assume Excavation will be to the same depth below finished grade as shown in contract drawings for similar projects with a slope of 1:2 for construction. - Assume material as 1.5 ft of organic, 10 ft of blastable cap rock, and inter-bedded formation of sand/shell and fragmented limestone for the remainder of the excavation. - Assume power will be provided from power lines approximately 2.5 miles away. - Assume that a diesel generator is needed for backup power.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

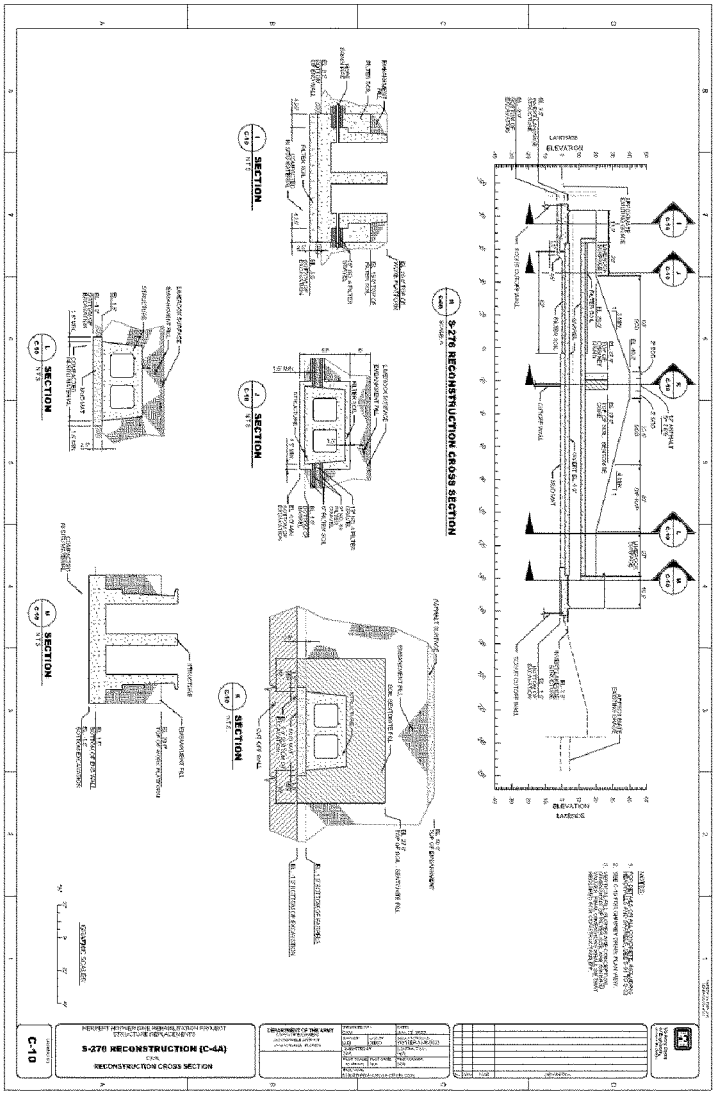
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	Survey of the site and installation of canal plugs. The culvert will have to breach the existing A-1 FEB levee and an inlet apron in both FEBS will be installed along with construction of the Culverts. Cast-in-place culverts will be formed and set along with the foundation for the gated inlet/outlet structures. Backfill and compaction around th canal portion of the culverts will be completed to restore flow to the existing seepage canal. The perimeter levee will be reconstructed and the gated structure construction will be completed. The plugs will be removed from the seepage canal between the two FEBS, and Support facilities (control station and generator shelters) will be constructed.

Key Outstanding Questions/Issues:	

Representative Drawings/Photos: S-628



Feature of Work:	FEB - S-628 (DS-9) Gate Culvert FEB Intake / Discharge structure between A-1 and A-2 FEB 930 CFS

Quantity Take Off:

Rim Ditch Excavation

Length	=	240.0	ft	Length of excavation						
Width	=	89.0	ft	Bottom width of excavation						
Canal Dimension	=	3ft deep x 3 ft wide								
Ditch volume	=	2,961.0	CF	=	109.7	BCY	=	137.1	LCY	

Canal Plug

Number	=	2.0	EA							
Top Width	=	100.0	FT							
Canal Width	=	73.0	FT							
Depth	=	14.5	FT							
Side Slope	=	3.0	:1							
bottom width	=	187.0	FT							
Volume	=	303,789.5	CF	=	11,251.5	ECY	=	12,714.2	LCY	

Levee Removal

Length	=	300.0	FT	assumed 300 ft of A-1 Perimeter levee will need to be removed.						
Height	=	11.3	FT	assumed						
Top Width	=	14.0	FT	assumed						
Side Slope	=	3.0	:1							
Bottom Width	=	81.8	FT							
Volume	=	162,381.0	CF	=	6,014.1	BCY	=	7,517.6	LCY	

Culvert excavation

Length	=	240.0	FT		0.0	Miles =	240.0			
Total Depth	=	26.0	FT	assumed same as S-624						
Thickness of Organic	=	1.5	FT							
Thickness of Blasted Cap Rock	=	10.0	FT							
Thickness of Inter-bedded material	=	14.5	FT							
Slope1	=	2.0	:1							
Slope2	=	2.0	:1							
Bottom Width	=	89.0	FT							
Top Width	=	193.0	FT							
Cross Section	=	3,666.0	SF							
Cross Section Organic	=	285.0	SF							
Cross section Blasted Cap Rock	=	1,670.0	SF							
Cross Section Inter-bedded Material	=	1,711.0	SF							
Surface Area of Canal	=	46,320.0	SF	=	1.1	ACRE				
Organic Volume	=	68,400.0	CF	=	2,533.3	BCY	=	3,166.7	LCY	
Blasted Cap Rock Volume	=	400,800.0	CF	=	14,844.4	BCY	=	18,555.6	LCY	
Inter-bedded Material Volume	=	410,640.0	CF	=	15,208.9	BCY	=	22,813.3	LCY	
		TOTAL		=	32,586.7	BCY				

Concrete Culvert Concrete

Length	=	140.0	FT							
Foundation Concrete										
Bottom Width	=	29.0	FT							
Bottom Thickness	=	2.5	FT							
Volume	=	10,150.0	CF	=	375.9	CY				
Vertical concrete										
Height	=	9.0	FT							
width of walls	=	8.8	FT							
Volume	=	11,025.0	CF	=	408.3	CY				
Elevated Concrete										
Top Width	=	25.5	FT							
Thickness	=	2.5	FT							
Volume	=	8,925.0	CF	=	330.6	CY				
PVC water stops	=	2.0	EA							
length	=	93.5	LF							
Spacing	=	15.0	FT							
total length	=	1,870.0	LF							

Inlet and Outlet Works

Number	=	8.0	EA							assumed intake and outlet are the same assumed 2 per each end gate and bulkhead
Foundation										
Length	=	8.0	FT							
Depth	=	5.0	FT							
Width	=	47.0	FT							
Volume	=	7,520.0	CF	=	278.5	CY				
Head Walls										
Height	=	25.5	FT							
Thickness	=	3.0	FT							
width	=	35.0	FT							
openings	=	162.0	SF							
volume	=	8,766.0	CF	=	324.7	CY				
End walls										
height	=	24.0	FT							
length	=	100.0	FT							total each side
thickness	=	2.0	FT							
volume	=	9,600.0	CF	=	355.6	CY				

MISC METALS

Railing	=	358.0	LF							
Ladders	=	4.0	EACH							
height	=	25.5	FT EA	=	102.0	FT		TOTAL		
Grating	=	400.0	SF per Gate							assumed 20 by 20 section of grating per gate per end.
TOTAL Grating	=	1,600.0	SF							

Gates IN HHD

Height	=	14.0	FT							*** STAINLESS STEEL
Width	=	10.0	FT							
Weight	=	6,500.0	LB							
Weight Per SF	=	46.4	LB/SF							

NEW GATES

number of gates	=	8.0	EA							assumed 2 on each end 1 gate and one bulkhead.
Height	=	16.0	FT							assumed 2 ft larger then similar gate
Width	=	12.0	FT							assumed 2 ft larger then similar gate
Weight % larger	=	10.0	%							assumed
Total Weight of gates	=	9,805.7	LB EA	=	78,445.7	LB	=	39.2	TON	
Motors	=	8.0	EA							
Gear Reduction	=	8.0	EA							
Actuators	=	8.0	EA							
cable reels	=	8.0	EA							
Imbeds for gate	=	504.0	LF							
Gate Seal Length	=	448.0	LF							

Operations building

size	=	315.0	SF							21 x 15
Electrical	=	NEEDED								
Communications	=	NEEDED								

Backfill

Existing Levees	=	162,381.0	CF	=	6,014.1	ECY	=	6,795.9	LCY	
Area of Levee	=	24,540.0	SF	=	2,726.7	SY				
Area above Culvert	=	879,840.0	CF	=	32,586.7	ECY	=	36,822.9	LCY	

Plug Removal

Plugs	=	303,789.5	CF	=	11,251.5	BCY	=	14,064.3	LCY	

Cut off walls

	Number	=	2.0	EA			assumed one in the A-1 and one in the A-2 Perimeter Levee
	Soil Bentonite Fill						
	Height	=	25.0	FT			
	Width	=	49.0	FT			
	Thickness	=	8.0	FT			
	Volume	=	9,800.0	CF/EA	=	363.0	CY/EA
	Total Volume	=	725.9	CY			
	Cutoff Wall						
	Height	=	35.0	FT			
	Width	=	89.0	FT			
	Thickness	=	3.0	FT			
	Volume	=	9,345.0	CF/EA	=	346.1	CY/EA
	Area	=	3,115.0	SF/EA			
	Total Area	=	6,230.0	SF			

RIP RAP

	common both sides						
	number of placements	=	2.0	EA			1 each side
	Length	=	20.0	FT			
	Width	=	47.0	FT			
	thickness	=	4.0	FT			
	Volume	=	3,760.0	CF	=	139.3	CY
	TOTAL	=	278.5	ECY	=	445.6	TON

Boat Barrier

	number	=	2.0	EA			
	length	=	73.0	FT			
	total length	=	146.0	FT			

SWPPP

	Floating Silt Boom	=	730.0	FT			assumed 10 times the length of the canal
	Silt Fence	=	6,226.0	FT			

Site Fence

	Length	=	1,000.0	FT			Assumed
	gates	=	4.0	FT			assumed

Site Restoration

	area	=	4.2	Acre	=	20,328.0	SY

Feature of Work:	FEB - L-624 Levee FEB Perimeter Levee

Scope Given:	Perimeter Levee: 20 Miles, 11.3 ft high, 3:1 Slopes, top width 14 ft

Reference for Scope Basis:	Engineering Appendix dated March 2013 A.5.1 Levee Height and crown A5.3.3.1 Assumed Levee Height

Scope Assumptions:	- Assumed material must be removed to the level of the cap rock to allow for a stable levee foundation. Assumed side slopes of excavation at a 1:2 slope. Assumed the excavated area will be backfilled with levee material. - Assumed material type Organic Material: 1.5 ft thick material will be disposed of on site. - Assumed Plantings: All plantings on levees will be native grasses. - Access road: 6 inches of crushed limestone, 14 ft wide entire length of levee. - Assumed processing: 50% of the material will need processing prior to placement as levee and 50% of material ca be placed without the need for processing.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

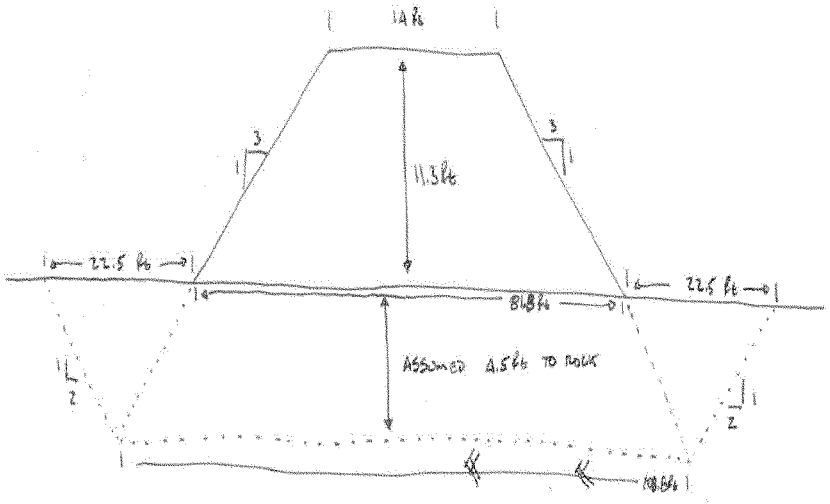
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	- Site survey and stake entire length and width of Levee. - Install silt fence and maintain as needed. - Excavate Organic Material to cap rock depth. Material will be disposed of onsite assumed side slopes of excavatio at 1V:2H. - Construct rim ditch for dewatering of levee base. - Build Levee compacting in 12 inch lifts. - Install slope protection on side of levee slopes. - Build access road on top of levee.

Key Outstanding Questions/Issues:	

Representative Drawings/Photos: L-624

L-624



* ALL AREA EXCAVATED WILL BE BACKFILLED W/ LEMKE CONSTRUCTION MATERIAL.

NTS

Feature of Work: L-624 Levee FEB Perimeter Levee

Quantity Take Off:

Levee Construction

Length	=	105,600.0	FT		20.0	Miles =	105,600.0	FT		
Height	=	11.3	FT							
Slope1	=	3.0	:1							
Slope2	=	3.0	:1							
Top width	=	14.0	FT							
Bottom Width	=	81.8	FT							
Cross Section	=	541.3	SF							
Surface Area of Levee	=	10,828,622.6	SF	=	248.6	ACRE				
Volume	=	57,158,112.0	CF	=	2,116,967.1	ECY	=	2,392,172.8	LCY	
base area of levee	=	8,638,080.0	SF	=	959,786.7	SY	=	198.3	Acre	
side slopes of levee	=	9,350,222.6	SF	=	1,038,913.6	SY	=	214.7	Acre	
roadway area	=	1,478,400.0	SF	=	164,266.7	SY	=	33.9	Acre	

Levee Sub Surface Excavation

Thickness of Organic	=	1.5	FT							
bottom width	=	90.8	FT							
Slope of Excavation	=	2.0	:1							
Top Width of Excavation	=	96.8	FT							
Excavation of Organic	=	140.7	SF							
Volume of Organic	=	14,857,920.0	CF	=	550,293.3	BCY	=	687,866.7	LCY	
Total Excavation	=	14,857,920.0	CF							
Total Backfill of Excavation	=	14,857,920.0	CF	=	550,293.3	ECY	=	621,831.5	LCY	
Road length	=	105,600.0	FT							
Road width	=	14.0	FT							
minimum thickness	=	0.5	FT							

Site Work

Silt Fence	=	211,200.0	LF							
Site Survey	=	10,222,080.0	SF	=	234.7	ACRE				

TOTAL BACKFILL AND FILL

Fill for excavation and levee	=	2,667,260.4	ECY	=	3,014,004.3	LCY				

Site Restoration

area next to levees	=	1,584,000.0	SF	=	176,000.0	SY				

Construction Haul Road

Length	=	105,600.0	FT							
Width	=	14.0	FT							
Area	=	1,478,400.0	SF	=	164,266.7	SY				
Thickness	=	1.0	FT							
Volume to Remove	=	54,755.6	BCY	=	68,444.4	LCY				

Rim Ditch Dewatering

Length	=	211,200.0	FT							
Dimensions	=	3 ft wide x 1.5 ft deep								
		950,400.0	CF	=	35,200.0	BCY	=	44,000.0	LCY	
Backfill	=	35,200.0	ECY	=	44,000.0					

Feature of Work:	FEB - L-625 Levee Interior Inflow Canal Levee

Scope Given:	Inflow Levee: 4 Miles, 11.3 ft high levee with 14 crown and 3:1 side slopes.

Reference for Scope Basis:	Engineering Appendix dated March 2013 A.5.1 Levee Height and crown width A5.3.3.1 Assumed Levee Height as assumed from levee design from perimeter levee

Scope Assumptions:	- Assumed material must be removed to the level of the cap rock to allow for a stable levee foundation. Assumed side slopes of excavation at a 1:2 slope. Assumed the excavated area will be backfilled with levee material. - Assumed material type Organic Material: 1.5 ft thick material will be disposed of on site. - Assumed Plantings: All plantings on levees will be native grasses. - Access road: 6 inches of crushed limestone, 14 ft wide entire length of levee. - Assumed processing: 50% of the material will need processing prior to placement as levee and 50% of material ca be placed without the need for processing.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

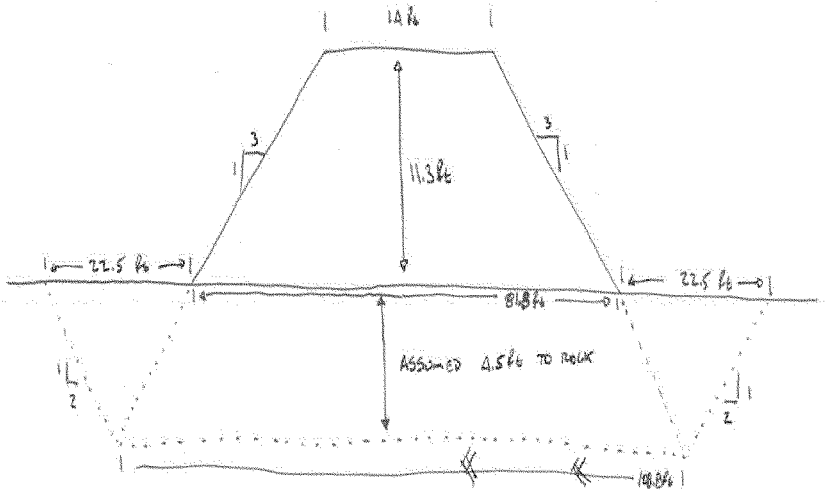
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	- Site survey and stake entire length and width of Levee. - Install silt fence and maintain as needed. - Excavate Organic Material to cap rock depth. Material will be disposed of onsite assumed side slopes of excavatio at 1V:2H. - Construct rim ditch for dewatering of levee base. - Build Levee compacting in 12 inch lifts. - Install slope protection on side of levee slopes. - Build access road on top of levee.

Key Outstanding Questions/Issues:	

Representative Drawings/Photos: L-625

L-625



* ALL AREA EXCAVATED WILL BE BACKFILLED W/ LEVEE CONSTRUCTION MATERIAL.

NTS

Feature of Work: FEB - L-625 Levee Interior Inflow Canal Levee

Quantity Take Off:

Levee Construction

Length	=	21,120.0	FT		4.0	Miles =	21,120.0	FT		
Height	=	11.3	FT							
Slope1	=	3.0	:1							
Slope2	=	3.0	:1							
Top width	=	12.0	FT							
Bottom Width	=	79.8	FT							
Cross Section	=	518.7	SF							
Surface Area of Levee	=	1,856,335.3	SF	=	42.6	ACRE				
Volume	=	10,954,310.4	CF	=	405,715.2	ECY	=	458,458.2	LCY	
base area of levee	=	1,685,376.0	SF	=	187,264.0	SY	=	38.7	Acre	
side slopes of levee	=	1,602,895.3	SF	=	178,099.5	SY	=	36.8	Acre	
roadway area	=	253,440.0	SF	=	28,160.0	SY	=	5.8	Acre	

Levee Sub Surface Excavation

Thickness of Organic	=	1.5	FT							
Total depth	=	1.5	FT							
bottom width	=	88.8	FT							
Slope of Excavation	=	2.0	:1							
Top Width of Excavation	=	94.8	FT							
Excavation of Organic	=	137.7	SF							
Volume of Organic	=	2,908,224.0	CF	=	107,712.0	BCY	=	134,640.0	LCY	
Total Backfill of Excavation	=	2,908,224.0	CF	=	107,712.0	ECY	=	121,714.6	LCY	
Road length	=	21,120.0	FT							
Road width	=	14.0	FT							
minimum thickness	=	0.5	FT							

Site Work

Silt Fence	=	42,240.0	LF			
Site Survey	=	2,002,176.0	SF	=	46.0	ACRE

TOTAL BACKFILL AND FILL

Fill for excavation and levee	=	513,427.2	ECY	=	580,172.7	LCY

Site Restoration

area next to levees	=	316,800.0	SF	=	35,200.0	SY

Construction Haul Road

Length	=	21,120.0	FT			
Width	=	12.0	FT			
Area	=	253,440.0	SF	=	28,160.0	SY
Thickness	=	1.0	FT			
Volume to Remove	=	9,386.7	BCY	=	11,733.3	LCY

Rim Ditch Dewatering

Length	=	42,240.0	FT

Feature of Work:	FEB - C-624 Inflow Canal 1550 CFS West Side of FEB

Scope Given:	Inflow Canal 4 Miles(21,120 FT), 9 ft deep canal, bottom width 40 ft, includes left side slope 2:1 and right side slope 2:1

Reference for Scope Basis:	Engineering Appendix dated March 2013 Paragraph A.5.3.3.2.1.3 Canals TABLE A-4. C-624 Gravity inflow Canal

Scope Assumptions:	- Assume material type Organic Material: 1.5 ft thick material will be disposed of on site. - Cap Rock excavation: 10 ft thick cap rock will need blasting. All rock excavation will need processing to be used in a structural manor for a levee. - Remainder of excavation is an inter-bedded formation of sand/shell and fragmented limestone. - Agricultural canals frequency: 60 (counted from Google Earth) canals will need to be backfilled intersecting ag canals. Assumed dimensions of 12 ft wide 3 ft deep with a 4 ft bottom width assumed a 100 ft long plug will be needed.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

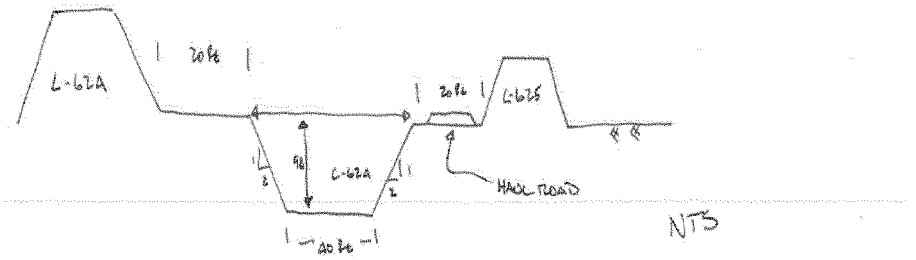
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope and assumptions were documented and sent to the design team for review. After reaching consensus on the scope and major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	'- Site survey and stake entire length and width of canal. - Install silt fence and maintain as needed. - Clear and grub entire site to remove vegetation and organic materials. - Construct a haul road parallel to the canal. This will be ongoing as needed during construction of the canal. Haul road maintenance will be ongoing during construction of the canal. Assumed same length as the canal will stay in place after construction. Assumed width of 14 ft 1 ft thick. - Excavate material from haul road allow to drain excess water. - Backfill of intersecting agricultural canals as needed.

Key Outstanding Questions/Issues:	

Representative Drawings/Photos: C-624

C-624



Feature of Work: FEB - C-624 Inflow Canal 1550 CFS West Side of FEB

Quantity Take Off:

Canal Excavation Pete Layer Common Layer and Rock Layer

Length	=	21,120.0	FT			4.0	Miles =	21,120.0	ft	
Total Depth	=	9.0	FT							
Thickness of Organic	=	1.5	FT							
Thickness of Blasting Cap Rock	=	7.5	FT							
Slope1	=	2.0	:1				Silt Fence =	42,392.0	ft	
Slope2	=	2.0	:1							
Bottom Width	=	40.0	FT				Silt boom =	1,216.0	ft	
Top Width	=	76.0	FT							
Cross Section	=	522.0	SF							
Cross Section Organic	=	109.5	SF							
Cross Section of Blasting Cap Rock	=	412.5	SF							
Surface Area of Canal	=	1,605,120.0	SF	=	36.8	ACRE				
Organic Volume	=	2,312,640.0	CF	=	85,653.3	BCY	=	107,066.7	LCY	
Blasted Cap Rock Volume	=	8,712,000.0	CF	=	322,666.7	BCY	=	484,000.0	LCY	

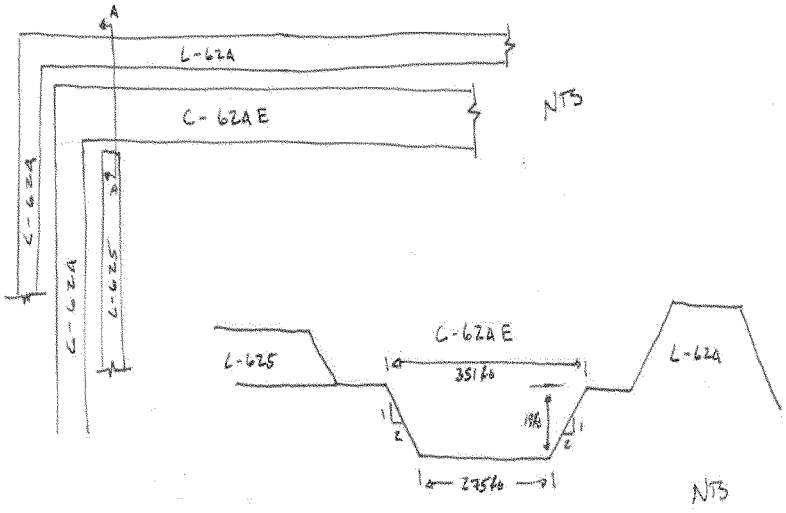
Haul road length	=	21,120.0	FT			
Haul road width	=	14.0	FT			
Haul road thickness	=	1.0	FT			
Haul Road Area	=	295,680.0	SF	=	32,853.3	SY
Back Fill Existing Ag Canal	=	60.0	ea			
Ag Canal						
Length of plug	=	100.0	FT			
Top width	=	12.0	FT			
bottom width	=	4.0	FT			
depth	=	3.0	FT			
Cross section	=	72.0	SF			
Volume	=	7,200.0	CF EA	=	266.7	ECY
TOTAL Volume	=	432,000.0	CF	=	16,000.0	ECY

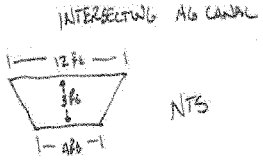
=	301.3	LCY		
=	18,080.0	LCY		

Feature of Work:	FEB - C-624E Spreader Canal Northern Boundary of FEB

Scope Given:	Distribution/Spreader Canal: 4 Miles long, bottom width 275 ft, 2:1 slopes both sides.
Reference for Scope Basis:	Engineering Appendix dated March 2013 Table A-6 C-624E Spreader Canal
Scope Assumptions:	- Organic Material: 1.5 ft thick - Cap rock excavation: 10 ft thick - Remaining Excavation: inter bedded formation. - Agricultural canals frequency: 13 (counted from Google Earth) canals will need to be backfilled intersecting ag canals. Assumed dimensions of 12 ft wide 3 ft deep with a 4 ft bottom width assumed a 100 ft long plug will be needed.
Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.
Sequence of Work:	- Site survey and stake entire length and width of Levee. - Install silt fence and maintain as needed. - Excavate Organic Material, material will be disposed of onsite. - Construct a haul road parallel to the canal. This will be ongoing as needed during construction of the canal. Haul road maintenance will be ongoing during construction of the canal. Assumed same length as the canal will be removed after construction. Assumed width of 14 ft 1 ft thick. - Excavate material into haul truck. - Backfill of intersecting agricultural canals.
Key Outstanding Questions/Issues:	

Representative Drawings/Photos: C-624E





NTS

C-624E

Feature of Work: FEB - C-624E Spreader Canal Northern Boundary of FEB

Quantity Take Off:

Canal Excavation Pete Layer Common Layer and Rock Layer

Length	=	21,120.0	FT		4.0	Miles =	21,120.0	ft		
Total Depth	=	19.0	FT							
Thickness of Organic	=	1.5	FT							
Thickness of Cap Rock	=	10.0	FT			Silt Fence =	42,942.0	ft		
Thickness of Inter bedded Formation		7.5	FT							
Slope1	=	2.0	:1							
Slope2	=	2.0	:1			Silt Boom =	5,616.0	ft		
Bottom Width	=	275.0	FT							
Top Width	=	351.0	FT							
Cross Section	=	5,947.0	SF							
Cross Section Organic	=	522.0	SF							
Cross Section Cap Rock	=	3,250.0	SF							
Cross section Inter Bedded Formation	=	2,175.0	SF							
Surface Area of Canal	=	7,413,120.0	SF	=	170.2	ACRE				
Organic Volume	=	11,024,640.0	CF	=	408,320.0	BCY	=	510,400.0	LCY	
Cap Rock Volume	=	68,640,000.0	CF	=	2,542,222.2	BCY	=	3,813,333.3	LCY	
Inter Bedded Formation Volume	=	45,936,000.0	CF	=	1,701,333.3	BCY	=	2,552,000.0	LCY	
backfill existing ag canals	=	13.0	EA							
Haul road length	=	21,120.0	FT							
Haul road width	=	14.0								
Haul road thickness	=	1.0	FT							
Area	=	295,680.0	SF	=	32,853.3	SY				
Ag Canal										
Length of plug	=	100.0	FT							
Top width	=	12.0	FT							
bottom width	=	4.0	FT							
depth	=	3.0	FT							
Cross section	=	72.0	SF							
Volume	=	7,200.0	CF EA	=	266.7	ECY	=	301.3	LCY	
TOTAL Volume	=	93,600.0	CF	=	3,466.7	ECY	=	3,917.3	LCY	

Feature of Work:	FEB - C-625E Collection Canal 400 CFS FEB interior collection Canal Along Southern Perimeter

Scope Given:	FEB collection canal along the southern boundary of the FEB. Length 6.0 miles aide slopes 1:2, bottom width 10 ft depth 9.0 ft from north elevation to canal bottom elevation.

Reference for Scope Basis:	Engineering Appendix dated March 2013 TABLE A-7. C-625E COLLECTION CANAL EXISTING CONDITIONS

Scope Assumptions:	- Assume material type Organic Material: 1.5 ft thick material will be disposed of on site. - Cap Rock excavation: 10 ft thick cap rock will need blasting. All rock excavation will need processing to be used in structural manor for a levee. - Remainder of excavation is an inter-bedded formation of sand/shell and fragmented limestone. - Agricultural canals frequency: 11 (counted from Google Earth) canals will need to be backfilled intersecting ag canals. Assumed dimensions of 12 ft wide 3 ft deep with a 4 ft bottom width assumed a 100 ft long plug will be needed.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

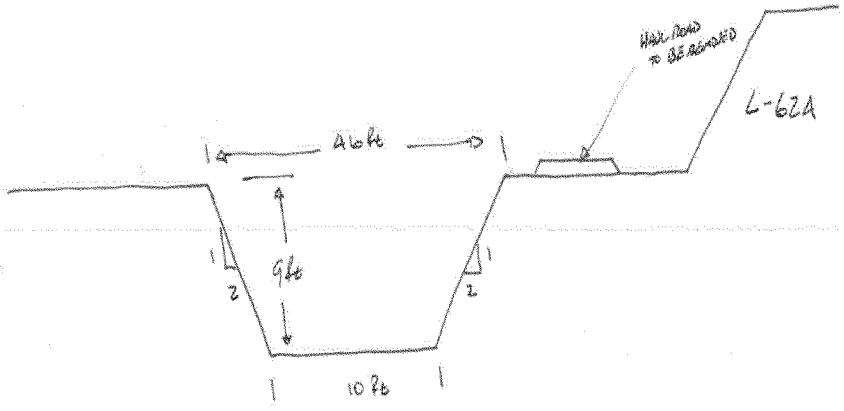
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	- Site survey and stake entire length and width of canal. - Install silt fence and maintain as needed. - Clear and grub entire site to remove vegetation and organic materials. - Construct a haul road parallel to the canal. This will be ongoing as needed during construction of the canal. Haul road maintenance will be ongoing during construction of the canal. Assumed same length as the canal will stay in place after construction. Assumed width of 14 ft 1 ft thick. - Excavate material from haul road allow to drain excess water. - Backfill of intersecting agricultural canals as needed.

Key Outstanding Questions/Issues:	

Representative Drawings/Photos: C-625E

C-625 E



NTS

Feature of Work:	FEB - C-625E Collection Canal 400 CFS FEB interior collection Canal Along Southern Perimeter

Quantity Take Off:

Canal Excavation Pete Layer Common Layer and Rock Layer

Length	=	31,680.0	FT			6.0	Miles =	31,680.0	ft		
Total Depth	=	9.0	FT								
Thickness of Organic	=	1.5	FT								
Thickness of Blasting Cap Rock	=	7.5	FT				Silt Fence =	63,360.0	FT		
Slope1	=	2.0	:1								
Slope2	=	2.0	:1								
Bottom Width	=	10.0	FT				Silt Boom =	1,104.0	Ft		
Top Width	=	46.0	FT								
Cross Section	=	252.0	SF								
Cross Section Organic	=	64.5	SF								
Cross Section of Blasting Cap Rock	=	187.5	SF								
Surface Area of Canal	=	1,457,280.0	SF	=		33.5	ACRE				
Organic Volume	=	2,043,360.0	CF	=		75,680.0	BCY	=	94,600.0	LCY	
Blasted Cap Rock Volume	=	5,940,000.0	CF	=		220,000.0	BCY	=	330,000.0	LCY	
backfill existing ag canals	=	11.0	EA								
Haul road length	=	31,680.0	FT								
Haul road width	=	14.0	FT								
Haul road thickness	=	1.0	FT								
Area of Haul Road	=	443,520.0	SF	=		49,280.0	SY				
Ag Canal											
Length of plug	=	100.0	FT								
Top width	=	12.0	FT								
bottom width	=	4.0	FT								
depth	=	3.0	FT								
Cross section	=	72.0	SF								
Volume	=	7,200.0	CF	EA	=	266.7	ECY	=	301.3	LCY	
TOTAL Volume	=	79,200.0	CF		=	2,933.3	ECY	=	3,314.7	LCY	

Feature of Work:	FEB - C-625W OUTFLOW CANAL 1.5 MILE LENGTH 1550 CFS

Scope Given:	The C-625W canal serves as the FEB discharge canal, extending from the S-625 discharge structure to the headwate of G-372 pump station. The existing canal currently serves as the seepage canal for the STA 3/4 Supply Canal, but w be modified to accommodate the FEB discharges. The existing canal will be extended northward and westward of t G-372 pump station to create a tie-in at the headwater of the structure. The canal will have a 1V:5H transition from elevation 0.0 ft NGVD where outlet structure S-625 ties into the canal, down to elevation -5.0 ft NGVD for conveyance capacity purposes. Design data for C-625W is summarized in Table A-8 and Table A-9.

Reference for Scope Basis:	Engineering Appendix dated March 2013 TABLE A-8. C-625W FEB DISCHARGE CANAL

Scope Assumptions:	- Assume material type Organic Material; 1.5 ft thick material will be disposed of on site. - Cap Rock excavation; 10 ft thick cap rock will need blasting. All rock excavation will need processing to be used in structural manor for a levee. - Remainder of excavation is an inter-bedded formation of sand/shell and fragmented limestone. - Agricultural canals frequency: 4 (counted from Google Earth) canals will need to be backfilled intersecting ag canals. Assumed dimensions of 12 ft wide 3 ft deep with a 4 ft bottom width assumed a 100 ft long plug will be needed.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

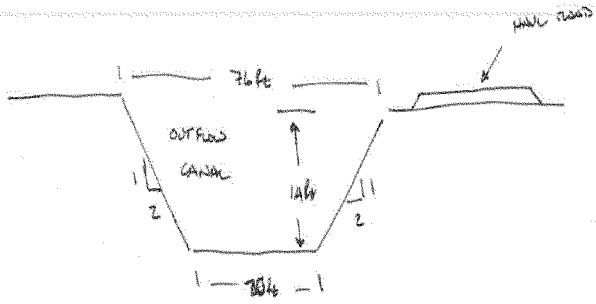
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope and assumptions were documented and sent to the design team for review. After reaching consensus on the scope and major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	'- Site survey and stake entire length and width of canal. - Install silt fence and maintain as needed. - Clear and grub entire site to remove vegetation and organic materials. - Construct a haul road parallel to the canal. This will be ongoing as needed during construction of the canal. Haul road maintenance will be ongoing during construction of the canal. Assumed same length as the canal will stay in place after construction. Assumed width of 14 ft 1 ft thick. - Excavate material from haul road allow to drain excess water. - Backfill of intersecting agricultural canals as needed.

Key Outstanding Questions/Issues:	

Representative Drawings/Photos: C-625W

C-625 W



Feature of Work: FEB - C-625W OUTFLOW CANAL 1.5 MILE LENGTH 1550 CFS

Quantity Take Off:

Canal Excavation Pete Layer Common Layer and Rock Layer

Length	=	7,900.0	FT		1.5	Miles =	7,920.0	ft		
Total Depth	=	14.0	FT			approximately 1.5 miles table listed at 7900 ft				
Thickness of Organic	=	1.5	FT							
Thickness of Blasting Cap Rock	=	10.0	FT							
Thickness inter-bedded material		2.5	FT			Silt Fence =	15,952.0	FT		
Slope1	=	2.0	:1			Silt Boom =	456.0	FT		
Slope2	=	2.0	:1							
Bottom Width	=	20.0	FT							
Top Width	=	76.0	FT							
Cross Section	=	672.0	SF							
Cross Section Organic	=	109.5	SF							
Cross Section of Blasting Cap Rock	=	500.0	SF							
Cross section Inter-Bedded Material	=	62.5	SF							
Surface Area of Canal	=	600,400.0	SF	=	13.8	ACRE				
Organic Volume	=	865,050.0	CF	=	32,038.9	BCY	=	40,048.6	LCY	
Blasted Cap Rock Volume	=	3,950,000.0	CF	=	146,296.3	BCY	=	219,444.4	LCY	
Inter-bedded Material Volume	=	493,750.0	CF	=	18,287.0	BCY	=	27,430.6	LCY	
backfill existing ag canals	=	6.0	EA							
Haul road length	=	7,900.0	FT							
Haul road width	=	14.0	FT							
Haul road thickness	=	1.0	FT							
Area of Haul Road	=	110,600.0	SF	=	12,288.9	SY				
Ag Canal										
Length of plug	=	100.0	FT							
Top width	=	12.0	FT							
bottom width	=	4.0	FT							
depth	=	3.0	FT							
Cross section	=	72.0	SF							
Volume	=	7,200.0	CF EA	=	266.7	ECY	=	301.3	LCY	
TOTAL Volume	=	43,200.0	CF	=	1,600.0	ECY	=	1,808.0	LCY	

Feature of Work:	FEB - C-626 SEEPAGE CANAL

Scope Given:	Seepage Canal: 11 Miles 14.5 ft deep 15 ft bottom width 73 ft top width and 2:1 slopes.

Reference for Scope Basis:	Engineering Appendix dated March 2013 Table A-10. C-626 Seepage Canal Collection Canal

Scope Assumptions:	- Assume material type Organic Material: 1.5 ft thick material will be disposed of on site. - Cap Rock excavation: 10 ft thick cap rock will need blasting. All rock excavation will need processing to be used in structural manor for a levee. - Remainder of excavation is an inter-bedded formation of sand/shell and fragmented limestone. - Agricultural canals frequency: 40 (counted from Google Earth) canals will need to be backfilled intersecting ag canals. Assumed dimensions of 12 ft wide 3 ft deep with a 4 ft bottom width assumed a 100 ft long plug will be needed.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

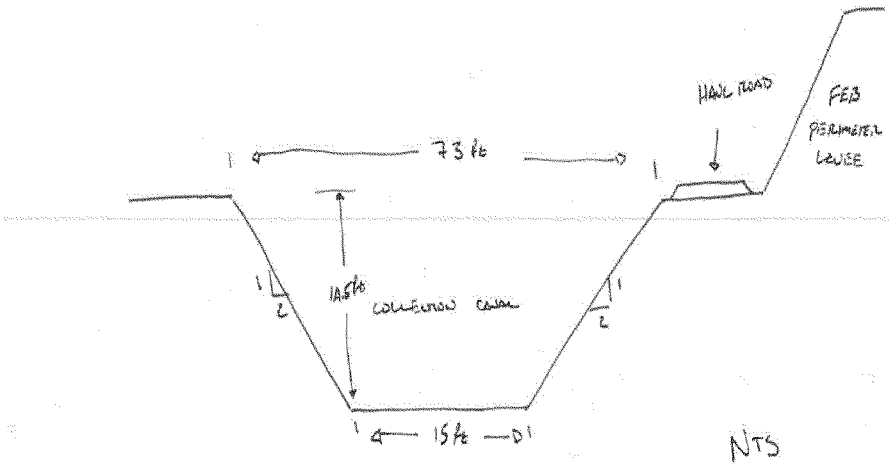
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	'- Site survey and stake entire length and width of canal. - Install silt fence and maintain as needed. - Clear and grub entire site to remove vegetation and organic materials. - Construct a haul road parallel to the canal. This will be ongoing as needed during construction of the canal. Haul road maintenance will be ongoing during construction of the canal. Assumed same length as the canal will stay in place after construction. Assumed width of 14 ft 1 ft thick. - Excavate material from haul road allow to drain excess water. - Backfill of intersecting agricultural canals as needed.

Key Outstanding Questions/Issues:	

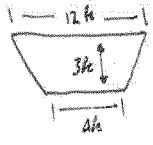
Representative Drawings/Photos: C-626

SEEPAGE COLLECTION CANAL C-626



NTS

INTERSECTING AG CANAL



NTS

Feature of Work: FEB - C-626 SEEPAGE CANAL

Quantity Take Off:

Canal Excavation Pete Layer Common Layer and Rock Layer

Length	=	58,080.0	FT			11.0	Miles =	58,080.0	ft		
Total Depth	=	14.5	FT								
Thickness of Organic	=	1.5	FT								
Thickness of Blasting Cap Rock	=	10.0	FT				Silt Fence =	116,306.0	FT		
Thickness inter-bedded material		3.0	FT								
Slope1	=	2.0	:1				Silt Boom =	3,212.0	Ft		
Slope2	=	2.0	:1								
Bottom Width	=	15.0	FT								
Top Width	=	73.0	FT								
Cross Section	=	638.0	SF								
Cross Section Organic	=	105.0	SF								
Cross Section of Blasting Cap Rock	=	470.0	SF								
Cross section Inter-Bedded Material	=	63.0	SF								
Surface Area of Canal	=	4,239,840.0	SF	=	97.3	ACRE	471,093.3				
Organic Volume	=	6,098,400.0	CF	=	225,866.7	BCY	=	282,333.3	LCY		
Blasted Cap Rock Volume	=	27,297,600.0	CF	=	1,011,022.2	BCY	=	1,516,533.3	LCY		
Inter-bedded Material Volume	=	3,659,040.0	CF	=	135,520.0	BCY	=	203,280.0	LCY		

Intersecting ag Canals

backfill existing ag canals	=	40.0	EA								
Haul road length	=	58,080.0	FT								
Haul road width	=	14.0	FT								
Haul road thickness	=	1.0	FT								
Haul road area	=	813,120.0	SF	=	90,346.7	SY					
Ag Canal											
Length of plug	=	100.0	FT								
Top width	=	12.0	FT								
bottom width	=	4.0	FT								
depth	=	3.0	FT								
Cross section	=	72.0	SF								
Volume Each	=	7,200.0	CF EA	=	266.7	ECY	=	301.3	LCY		
TOTAL Volume	=	288,000.0	CF	=	10,666.7	ECY	=	12,053.3	LCY		

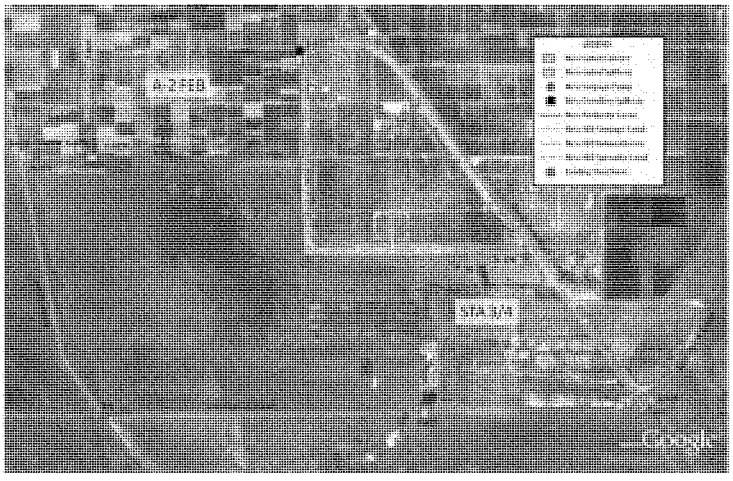
Cut Fill Study

	Excavation									
	organic		common		Blasted Cap Rock		Inter-Bedded Material		Levee Material	
Structure	BCY	LCY	BCY	LCY	BCY	LCY	BCY	LCY	BCY	LCY
S-623	-	-	10,133.3	12,666.7	-	-	-	-	-	-
S-624	4,615.0	5,768.8	-	-	27,444.4	41,166.7	29,699.0	44,548.5	7,723.9	9,654.8
S-625	1,777.8	2,222.2	-	-	9,817.4	14,726.2	-	-	-	-
S-626	800.0	1,000.0	-	-	1,777.8	2,666.7	1,291.1	1,936.7	-	-
S-627	-	-	-	-	-	-	-	-	1,336.3	1,670.4
S-628	2,533.3	3,166.7	-	-	14,844.4	22,266.7	15,318.6	22,977.8	6,014.1	7,517.6
L-624	550,293.3	687,866.7	-	-	-	-	-	-	-	-
L-625	107,712.0	134,640.0	-	-	-	-	-	-	-	-
C-624	85,653.3	107,066.7	-	-	322,666.7	484,000.0	-	-	-	-
C-624E	408,320.0	510,400.0	-	-	2,542,222.2	3,813,333.3	1,701,333.3	2,552,000.0	-	-
C-625E	75,680.0	94,600.0	-	-	220,000.0	330,000.0	-	-	-	-
C-625W	32,038.9	40,048.6	-	-	146,296.3	219,444.4	18,287.0	27,430.6	-	-
C-626	225,866.7	282,333.3	-	-	1,011,022.2	1,516,533.3	135,520.0	203,280.0	-	-
TOTAL	1,495,290.3	1,869,112.9	10,133.3	12,666.7	4,296,091.5	6,444,137.3	1,901,449.0	2,852,173.6	15,074.3	18,842.8

	Fill	
	Levee Quality Material	
Structure	ECY	LCY
S-623	3,555.6	4,017.8
S-624	69,315.0	78,325.9
S-625	11,488.9	12,982.4
S-626	382.2	431.9
S-627	200.4	226.5
S-628	38,600.8	43,618.9
L-624	2,667,260.4	3,014,004.3
L-625	513,427.2	580,172.7
C-624	16,000.0	18,080.0
C-624E	3,466.7	3,917.3
C-625E	2,933.3	3,314.7
C-625W	1,600.0	1,808.0
C-626	10,666.7	12,053.3
TOTAL	3,338,897.2	3,772,953.8

Processed LCY	=	9,327,820.3	LCY
Needed LCY	=	3,772,953.8	LCY
rejected/unused processed	=	5,554,866.5	LCY
Needs Removed From Site	=	59.55%	
		299,058.1	
		2,521,004.7	
		2,333.3	

South of the Redline – Diversion and Conveyance





Feature of Work:	S-620 (CS-1) Gated Culvert 500 CFS In L-6 Canal

Scope Given:	S-620 is proposed to be a two-barreled 8 ft by 8 ft gated box culvert to control outflow from the L-6 Canal to the L- Canal. The structure will replace the existing plug. S-620 will be located at the southern end of the L-6 Canal, approximately 0.15 miles north of S-7. The structure is an outlet control structure to allow conveyance from the L-6 Canal to the eastern (remnant) L-5 Canal, replacing the existing plug at the most southern end of the L-6 Canal. S-6 is a two-barreled gated box culvert structure. The design flow is 500 cfs with a design hydraulic head of 0.5 ft. The structure is a typical box culvert with dimensions of 8 ft by 8 ft with vertical slide gates and a total length of 75 ft. T upstream and downstream inverts are set at elevation -3.5 ft NGVD. The design velocity through the structure is 4. fps.

Reference for Scope Basis:	Engineering Appendix, March 2013 and Annexes Existing Plug Removal A.6.3.3.2.1.1 Gated Culverts S-620 Gated Culvert (CS-1) A.6.4.4 Culverts A.6.4.1 General Status of Completed and Non-Executed Efforts A.6.5.2 General Status of Completed and Non-Executed Efforts Location Lat 26 20 12.36 Lon 80 32 11.83 A.6.1.5 Utility Relocations Table A-23. S-620 Gated Culvert

Scope Assumptions:	- Assume similar to structures S-276 and S-277. - Assume given dimensions in the engineering appendix govern over provided design documents for similar structu if no dimensions are given in the engineering appendix all dimensions will come from the similar structure. - Assume a canal plug will be utilized in concert with a rim ditch dewatering to install the culvert. -Assume Excavation will be to the same depth below finished grade as shown in contract drawings for similar projects. Assume existing plug is comprised of levee quality material and constructed to the same shape and the Ft perimeter levee. Assume any excavation below grade will blasted. - ASSUME power will be provided from power lines in the area approximately 1000'. - Assume that a diesel generator is needed for backup power.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

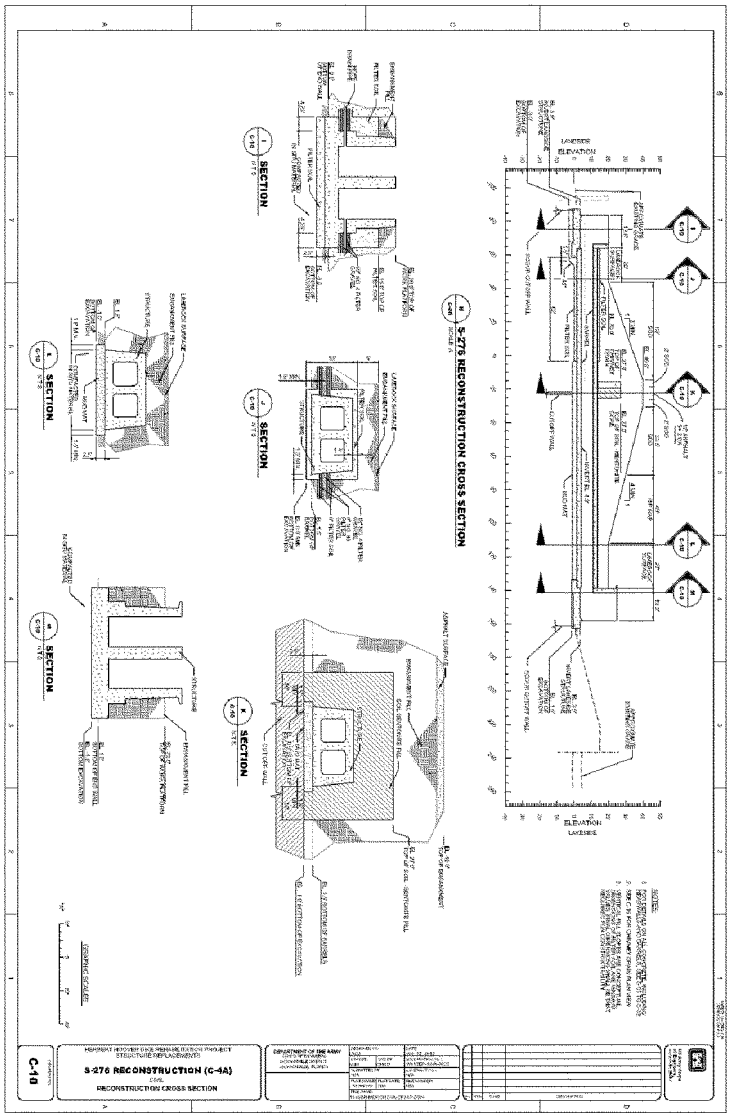
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope and assumptions were documented and sent to the design team for review. After reaching consensus on the scope and major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	- Construction will be performed after the canal plugs are installed up and downstream of the proposed culvert location. Dewatering will be needed, Dewatering pumps used as needed throughout Construction utilizing rim ditc Dewatering approach. Excavation/blasting of limestone rock will be required to allow space for the foundation for the gated culvert structure. Culverts, foundations and structures will then be placed. Control structures for the Culverts will be installed and A standalone Control station will be built in the area. An additional backup generator will be required along with local utility power. Apron, wing wall, and riprap placement will occur after Culverts hav been placed. Backfill and compaction around the structure will occur, the plugs will be removed.

Key Outstanding Questions/Issues:	

Representative Drawings/Photos: S-620



Feature of Work: S-620 (CS-1) Gated Culvert 500 CFS In L-6 Canal

Quantity Take Off:

Existing Plug Removal

Length	=	140.0	FT						
Height	=	24.0	FT						
Slope1	=	3.0	:1						
Slope2	=	3.0	:1						
Top width	=	14.0	FT						
Bottom Width	=	158.0	FT						
Cross Section	=	2,064.0	SF						
Surface Area of Levee	=	15,756.1	SF	=	0.4	ACRE			
Volume	=	288,960.0	CF	=	10,702.2	BCY	=	13,377.8	LCY
base area of levee	=	22,120.0	SF	=	2,457.8	SY	=	0.51	Acre
side slopes of levee	=	12,396.1	SF	=	1,377.3	SY	=	0.28	Acre
roadway area	=	1,960.0	SF	=	217.8	SY	=	0.04	Acre

Care and Diversion of water plug (two required)

Assume each is 80 ft long 24ft deep with 3:1 side slopes

Length	=	160.0	FT						
Height	=	24.0	FT						
Slope1	=	3.0	:1						
Slope2	=	3.0	:1						
Top width	=	5.0	FT						
Bottom Width	=	149.0	FT						
Cross Section	=	1,848.0	SF						
Surface Area of Levee	=	8,899.6	SF	=	0.2	ACRE			
Volume	=	295,680.0	CF	=	10,951.1	ECY	=	12,374.8	LCY
Plug Removal	=	10,951.1	BCY	=	13,688.9	LCY			

Culvert excavation

Length	=	140.0	FT						
Total Depth	=	3.0	FT						
Width	=	45.0	FT						
Blast Required Rock Volume	=	18,900.0	CF	=	700.0	BCY	=	1,050.0	LCY

Concrete Culvert Concrete

Length	=	140.0	FT						
Foundation Concrete									
Bottom Width	=	26.0	FT						
Bottom Thickness	=	2.5	FT						
Volume	=	9,100.0	CF	=	337.0	CY			
Vertical concrete									
Height	=	9.0	FT						
width of walls	=	10.0	FT						
Volume	=	12,600.0	CF	=	466.7	CY			
Elevated Concrete									
Top Width	=	23.5	FT						
Thickness	=	2.5	FT						
Volume	=	8,225.0	CF	=	304.6	CY			
PVC water stops	=	2.0	EA						
area	=	63.5	FT						
Spacing	=	15.0	FT						
Length	=	1,270.0	FT						

Inlet and Outlet Works

Number	=	8.0	EA		assumed intake/outlet are the same assumed 2 per each end gate and bulkhead		
Foundation							
Length	=	8.0	FT				
Depth	=	5.0	FT				
Width	=	41.0	FT				
Volume	=	6,560.0	CF	=	243.0	CY	
Head Walls							
Height	=	25.5	FT				
Thickness	=	3.0	FT				
width	=	29.5	FT				
openings	=	128.0	SF				
volume	=	7,491.0	CF	=	277.4	CY	
End walls							
height	=	24.0	FT				
length	=	100.0	FT		total either inlet or outlet		
thickness	=	2.0	FT				
volume	=	9,600.0	CF	=	355.6	CY	

Misc Metals

Railing	=	358.0	LF			
Ladders	=	4.0	EACH			
height	=	25.5	FT	=	102.0	FT Total
Grating	=	400.0	SF per Gate		assumed 20 by 20 section of grating per gate per end.	
TOTAL Grating	=	1,600.0	SF			

Gates IN HHD

Height	=	14.0	FT	*** STAINLESS STEEL for opening 7 by 7
Width	=	10.0	FT	
Weight	=	6,500.0	LB	
Weight Per SF	=	46.4	LB/SF	

NEW GATES

number of gates	=	8.0	EA	assumed 2 on each end 1 gate and one bulkhead.					
Height	=	15.0	FT	assumed 2 ft larger then similar gate					
Width	=	11.0	FT	assumed 2 ft larger then similar gate					
Weight % larger	=	10.0	%	assumed					
Total Weight of gates	=	8,426.8	LB EA	=	67,414.3	LB	=	33.7	TON
Motors	=	8.0	EA						
Gear Reduction	=	8.0	EA						
Actuators	=	8.0	EA						
cable reels	=	8.0	EA						
Imbeds for gate	=	496.0	LF						
Gate Seal Length	=	416.0	LF						

Operations building

size	=	315.0	SF	21 x 15
Electrical	=	NEEDED		
Communications	=	NEEDED		

Backfill

Area above Culvert	=	288,960.0	CF	=	10,702.2	ECY	=	12,093.5 LCY

RIP RAP

common both sides						
number of placements	=	2.0	EA	1 each side		
Length	=	20.0	FT			
Width	=	41.0	FT			
thickness	=	4.0	FT			
Volume	=	3,280.0	CF/EA	=	121.5	CY/EA
TOTAL VOLUME	=	243.0	ECY	=	388.7	TON

Boat Barrier

Number	=	2.0	EA
Length	=	140.0	FT
Total Length	=	280.0	FT

SWPPP

Silt Fence	=	620.0	FT
Floating Silt Boom	=	280.0	FT

Site Fence

Length	=	1,000.0	FT	Assumed
gates	=	2.0	FT	Assumed

Feature of Work:	S-621 (CS-2) Gated Spillway 2500 CFS on STA 3/4 Outflow Canal

Scope Given:	The spillway consists of three gates with dimensions of 23 ft wide by 13.5 ft high. The crest elevation is set to 1.0 ft NGVD. The upstream and downstream aprons are set at an elevation of -5.0 ft NGVD, with apron lengths of 30 ft. S 621 is located in line with the STA 3/4 Outflow Canal, just north of the L-5 Canal. The S-621 gated spillway is locate in the STA 3/4 Outflow Canal, and will be used to block flows from the STA 3/4 from entering the L-5 Canal when L- deliveries are being made.

Reference for Scope Basis:	Engineering Appendix, March 2013 and Annexes A.6.3.2.1.4 Water Control Structures A.6.3.3.2.1.2 Gated Spillways A.6.4.1 General Status of Completed and Non-Executed Efforts A.6.4.3 Overflow Spillways A.6.5.2 General Status of Completed and Non-Executed Efforts Location Lat 26 20 25 Lon 80 32 50.10 A.6.1.5 Utility Relocations

Scope Assumptions:	- Assume similar to structure S-65EX. - Assume given dimensions in the engineering appendix govern over provided design documents for similar structu if no dimensions are given in the engineering appendix all dimensions will come from the similar structure. - Assume bypass canal is the same shape as the existing STA3/4 outflow canal. Length is assumed as 1000 ft. Assun material as 4.5 ft of organic, 3 ft of rippable rock and the remainder will need blasting. - Assume aprons are in addition to the concrete structure shown in the provided drawings. - Assume power for the structure will be provided from local power lines located .5 miles from the structure. - Assume that a diesel generator is needed for backup power. - Assume 60 ft deep sheet pile 1000ft long. - Assume the canal will be plugged, in conjunction with sheet pile, upstream and downstream expanse of the existi canal. - Assume dewatering will be ongoing through feature of work. - Assume 35 KW Diesel Generator with 1000 gallon above ground tank.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

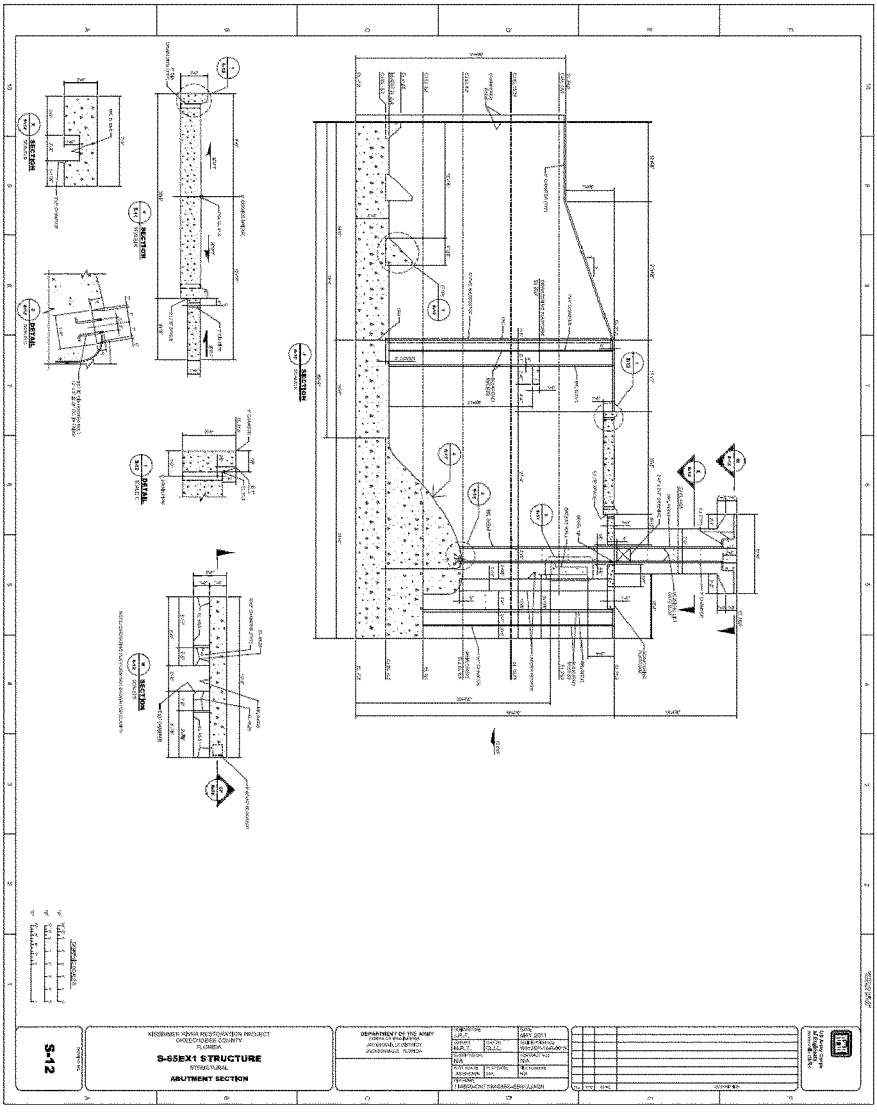
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	-A Bypass canal will be constructed around the location of S-621 to facilitate construction. -Sheet pile will be required to be installed around the entire structure and require 24/7 dewatering. - Excavation of materials to allow for construction of the foundation of the cross canal gate structure and the canal apron/wing wall. Construction of concrete work for structure followed by apron and wing walls. Backfill suitable material around the structure and import riprap. Construct control station, diesel generator, and fuel storage. Pla gates and other associated closure devices for the gate structure. Restore flow to canal and backfill/compact diversion canal.

Key Outstanding Questions/Issues:	

Representative Drawings/Photos: S-621



Feature of Work: S-621 (CS-2) Gated Spillway 2500 CFS on STA 3/4 Outflow Canal

Quantity Take Off:

Structure Dimensions and volumes

Number of Gates	=	3.0	EA				
Superstructure/Gate Structure							
tower cross section	=	144.9	SF				
number of towers	=	4.0	EA				
pier cross section	=	154.1	SF				
number of Piers	=	2.0	EA				
tower width	=	3.5	FT				
Pier Height	=	35.0	FT				
beam cross section	=	15.0	SF				
Beam Length	=	69.0	FT				
volume	=	12,815.6	CF	=	474.7	CY	
volume of elevated Beam	=	1,035.0	CF	=	38.3	CY	
Width	=	69.0	FT				
Cross section of platform,bridge,brestwall	=	46.5	SF				
Volume	=	3,211.3	CF	=	118.9	CY	
OGEE volume							
Cross section	=	143.9	SF				
width	=	69.0	FT				
OGEE Spillway volume	=	9,929.0	CF	=	367.7	CY	
Spillway wall volume (Abutment)	=	1,153.3	CY	Structure is 90' long and cross section of wall is 173 SF			
Approach apron	=	460.0	CY	Assumed 36ft long 89 ft wide and 5 ft thick per S-65EX design			
Stilling Basin	=	460.0	CY	Assumed 36ft long 89 ft wide and 5 ft thick per S-65EX design			

Wing Walls Assumed approach wing walls similar to downstream wing wall plan from S-65EX-1 with anchor walls. Construction will consist of driven sheet pile with a 2'x2' concrete pile cap. The anchor walls will be 1 ft thick reinforced concrete. Concrete anchor wall dimensions will match wing wall dimensions. The wing wall and concrete anchor wall will be connected by #10 all thread grade 70. A C8x18.75 channel will be attached to the back of the wing wall where the anchors will be attached to.

wing walls							
Number	=	4.0	Each				
Length average US and DS	=	95.5	FT				
US Depth	=	44.5	FT				
DS Depth	=	26.5	FT				
area of sheet pile	=	13,561.0	SF				
Pile Cap							
height	=	2.0	FT				
width	=	2.0	FT				
volume	=	56.6	CY				
Rod length	=	60.0	FT				
spacing	=	4.0	FT				
number of rods	=	96.0	EA	total length	=	5,760.0	
Anchor Walls							
height	=	8.0	FT				
thickness	=	1.0	FT				
length	=	382.0	FT				
volume	=	113.2	CY				
Rip Rap				Lengths and depths assumed to extend beyond aprons.			
Length	=	440.0	FT				
width	=	69.0	FT				
Depth	=	3.0	FT	average of all depths			
volume	=	3,373.3	CY	=	5,397.3	TON	

Excavation for Footing Volume	=	96,000.0	CF	Assume 89' wide (per width of channel) by 60 ft long (per S-65EX) and 10'
	=	3,555.6	BCY	deep to allow for construction of the underwater seal and structural
	=	5,333.3	LCY	footings.
Excavation east and west canal	=	139,200.0	CF	Assume top of bank is 13.5 ft NGVD (Per table A-24) and bottom of
banks for installation of wing	=	5,155.6	BCY	excavation and bottom of excavation is at -15.5 ft NGVD (Total depth 29').
	=	7,733.3	LCY	Assume excavation is 160 ft long and extends the bottom of the canal an additional 15' per bank. Assume material is common or rippable as it is the bank of a levee.
Sheet pile/cofferdam	=	1,000.0	LF	Assume 1000 LF of sheet pile/cofferdam to go around entire work site.
Area	=	60,000.0	SF	Sheet pile will be driven 60ft deep. All sheet pile used as a coffer dam will be removed.

Gate weight calculations

3/8" Plate steel	=	15.3	lb/sq ft				
1/2" Plate steel	=	20.4	lb/sq ft				
1" Plate Steel	=	40.8	lb/sq ft				
Gate Skin 3/8" Plate Steel	=	392.0	sq ft	Assume Gate dimensions of 14'x28'			
3/8" Plate stiffeners and seal angles	=	87.0	sq ft	Assume 5 sq ft for seal angles and 82 for stiffeners			
Horizontal C-Channels (1/2")	=	607.0	sq ft	Assume each channel is equivalent to 26"x28' (10 Channels).			
Vertical C-Channels (1/	=	303.0	sq ft	Assume each vertical channel is 26"x14' (10 Channels).			
Pull Pad eyes (1")	=	4.0	sq ft	Assume 4 pad eyes per gate @ 1 sq ft each			
Total 3/8" Plus 10% for misc. items	=	526.9	sq ft	=	8,061.6	lbs	
Total 1/2" plus 15% for misc items	=	1,046.5	sq ft	=	21,348.6	lbs	
Total 1" steel	=	4.0	sq ft	=	163.2	lbs	
lbs/sq ft for 28'x14' gate	=	75.4	lb/sq ft				
Area of single S-621 Gate	=	403.0	sq ft			assumed 3 ft bigger then opening in each direction	
Approximate weight of S-621 Gate	=	30,403.2	lb				
Overweight factor for larger gates (10%)	=	33,443.6	LB EA	=	16.7	TON Ea	3 Each Needed.

Precast Concrete Control Building / Generator Shelter

Shelter square footage	=	315.0	sq ft	
Excavation/backfill for shelter	=	163.3	ECY	Building will be set on grade with 12" capillary water barrier and geotextile fabric and a 12" thick concrete curb around the building perimeter.
Generator Fuel Tank	=	1000 Gallon		
Fuel Pad dimensions	=	96.0	SF	Assume 8'x12'x12" thick reinforced concrete slab on grade pad.

Gate embeds/seal lengths

Gate Dimensions						
Width	=	26.0	FT			
Height	=	15.5	FT			
Gate well Height	=	42.0	FT			
Gate Well Embed	=	110.0	FT			
Total gate Imbed length	=	330.0	FT	3 gates		
Seal Length	=	57.0	FT	seal length is the perimeter of bottom and both sides.		
Total Seal length	=	171.0	FT	total of 3 gates		
Up and Downstream Bulkhead Slot	=	588.0	FT	6 times vertical plus width of new gate per slot		
Bulkheads	=	33,443.6	LB EA	assume same size as gates		
number	=	6.0	EA	two per gate needed		
total length of imbeds	=	918.0	FT			
Total Weight of gates and stop logs	=	300,992.0	LB	=	150.5	TON
Total length of Seals stop logs and gates	=	513.0	FT			

Backfill

Backfill around structures	=	5,155.6	ECY	=	5,825.78	LCY

Railings and ladders

Railing				
Length	=	826.0	FT	assumed 4
Height	=	3.5	FT	
Ladders				
Count	=	6.0	EA	assumed ladders on each side of the structure.
Height	=	17.5	FT	average of all three types
total height	=	105.0	FT	

Boat Barrier

Number	=	2.0	EA	
Length each	=	205.0	FT	
Total Length	=	410	FT	

Site Fencing

Length	=	1,000.0	FT	assumed a total of 1000 LF of chain link fencing.
Gates	=	4.0	EA	assumed

SWPPP

Length	=	3,000.0	LF
Floating Silt Boom	=	615.0	LF

Access road

Length	=	300.0	FT	assumed		
Width	=	14.0	FT	assumed		
Area	=	4,200.0	SF	=	466.7	SY

Site Restoration

Area	=	2.0	ACRE	=	9,680.00	SY

Feature of Work:	S-622 (CS-3) Gated spillway 500 CFS In L-5 Canal

Scope Given:	S-622 is a gated spillway that will replace the existing plug in the L-5 Canal to hydraulically connect the eastern and western portions of the canal. S-622 is a three-bay gated spillway. The design flow is 500 cfs with a design hydrauli head of 0.1 feet. The spillway consists of three gates with dimensions of 15 ft wide by 10 ft high. The crest elevatio is set to 5.00 ft NGVD. The approach apron and discharge apron inverts are set at an elevation of 0.00 ft NGVD witl lengths of 33 ft. S-622 is located in line with the L-5 Canal, just south of the former Griffin rock pits near the southwest corner of STA 3/4. The S-622 gated spillway will replace the existing plug in the L-5 Canal, located near t rock pits at the southwest corner of the STA 3/4. The spillway was sized to match the L-6 deliveries quantity of 500 cfs.

Reference for Scope Basis:	Engineering Appendix, March 2013 and Annexes A.6.1.5 Utility Relocations A.6.3.2.1.4 Water Control Structures S-622 Gated Spillway (CS-3) Table A-25. S-622 Gated Spillway

Scope Assumptions:	- Assume similar to structure S-65EX. - Assume given dimensions in the engineering appendix govern over provided design documents for similar structu if no dimensions are given in the engineering appendix all dimensions will come from the similar structure. - Assume aprons are in addition to the concrete structure shown in the provided drawings. - Assume power for the structure will be provided from local power lines located .5 miles from the structure. - Assume that a diesel generator is needed for backup power. - Assume feature will be constructed internal to the existing plug utilizing excavated material to act as a plug in conjunction with rim ditch dewatering to dewater the site. - Assume dewatering will be ongoing through feature of work. - Assume 35 KW Diesel Generator with 1000 gallon above ground tank.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

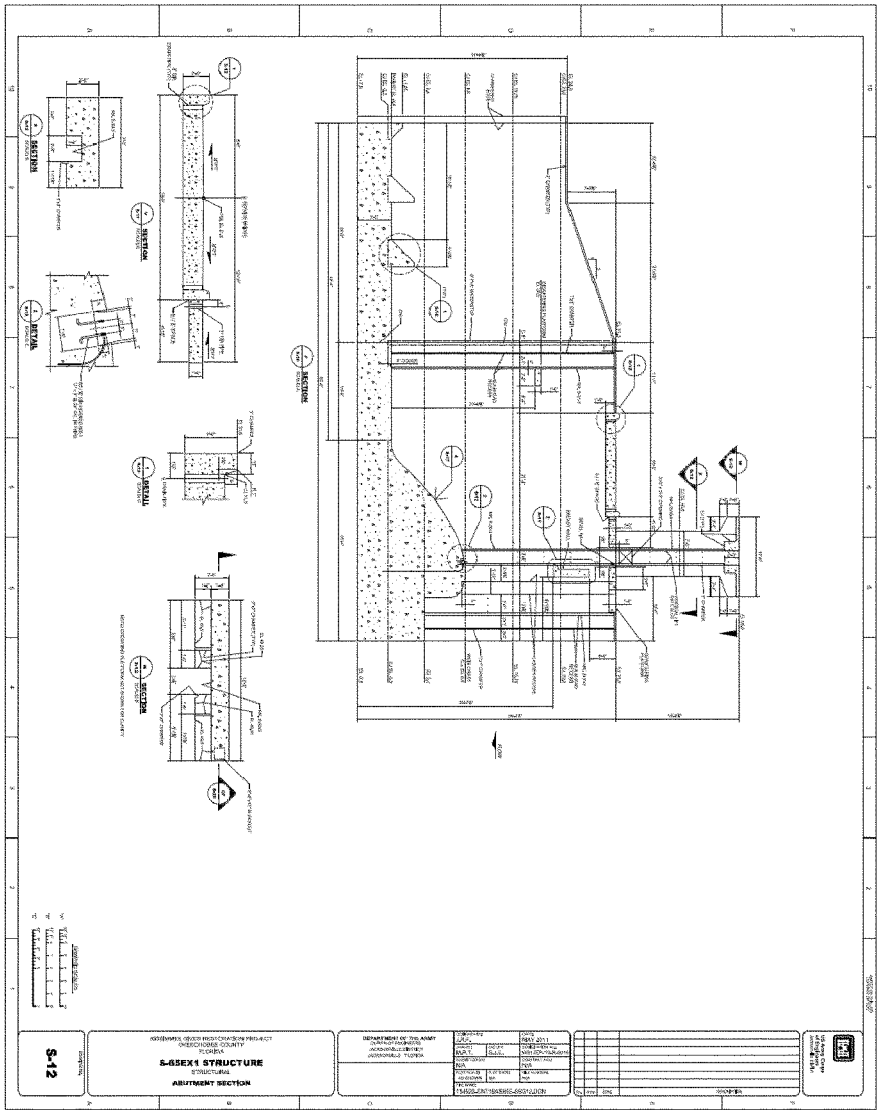
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	- Excavation of the existing plug and placement to act as plugs around the Construction site will be ongoing. rim ditch Dewatering will be utilized to dewater the site which will be ongoing during constrcution. - Excavation of materials to allow for Construction of the foundation of the cross canal gate structure and the cana Apron/wing wall. Construction of concrete work for structure followed by Apron and wing walls. Backfill suitable material around the structure and import riprap. Construct Control station, diesel generator, and fuel storage. Pla gates and other associated closure devices for the gate structure. Remove coffer dam and Remove existing plug ar the backfilled plug.

Key Outstanding Questions/Issues:	

Representative Drawings/Photos: S-622



Feature of Work: S-622 (CS-3) Gated spillway 500 CFS In L-5 Canal

Quantity Take Off:

Plug in L-5 East Canal Removal

Length	=	450.0	FT					
Top Width	=	100.0	FT					
depth	=	25.0	FT					
Slope	=	2.0	:1					
Bottom Width	=	200.0	FT					
Volume	=	1,687,500.0	CF	=	62,500.0	BCY	=	93,750.0 LCY

Structure Dimensions and volumes

Underwater Concrete Seal Volume (Unreinforced	=	3,851.9	CY	Underwater concrete is not reinforced, 10 ft thick 65 ft wide and 160 ft long				
Number of Gates	=	3.0	EA					
Superstructure/Gate Structure								
tower cross section	=	144.9	SF					
number of towers	=	4.0	EA					
pier cross section	=	154.1	SF					
number of Piers	=	2.0	EA					
tower width	=	3.5	FT					
Pier Height	=	35.0	FT					
beam cross section	=	15.0	SF					
Beam Length	=	45.0	FT					
volume	=	12,815.6	CF	=	474.7	CY		
Volume of Elevated Beam	=	675.0	CF	=	25.0	CY		
OGEE volume								
Cross section	=	143.9	SF					
width	=	45.0	FT					
OGEE Spillway volume	=	6,475.4	CF	=	239.8	CY		
Spillway wall volume (Abutment)	=	1,153.3	CY	Structure is 90' long and cross section of wall is 173 SF				
Approach apron	=	300.0	CY	Assumed 36ft long 45 ft wide and 5 ft thick per S-65EX design				
Stilling Basin	=	300.0	CY	Assumed 36ft long 45 ft wide and 5 ft thick per S-65EX design				

Wing Walls Assumed approach wing walls similar to downstream wing wall plan from S-65EX-1 with anchor walls. Construction will consist of driven sheet pile with a 2'x2' concrete pile cap. The anchor walls will be **1** ft thick reinforced concrete. Concrete anchor wall dimensions will match wing wall dimensions. The wing wall and concrete anchor wall will be connected by #10 all thread grade 70. A C8x18.75 channel will be attached to the back of the wing wall where the anchors will be attached to.

wing walls			
Number	=	4.0	Each
Length average US and DS	=	95.5	FT
US Depth	=	44.5	FT
DS Depth	=	26.5	FT
area of sheet pile	=	13,561.0	SF

Pile Cap						
height	=	2.0	FT			
width	=	2.0	FT			
volume	=	56.6	CY			
Rod length	=	60.0	FT			
spacing	=	4.0	FT			
number of rods	=	96.0	EA			
Total Length	=	5,760.0	LF			
Anchor Walls						
height	=	8.0	FT			
thickness	=	1.0	FT			
length	=	382.0	FT			
volume	=	113.2	CY			
Rip Rap				Lengths and depths assumed to extend beyond aprons.		
Length	=	440.0	FT			
width	=	45.0	FT			
Depth	=	3.0	FT	average of all depths		
volume	=	2,200.0	CY	=	3,520.0	TON

Excavation for Footing Volume	=	39,000.0	CF	Assume 65' wide (per width of channel) by 60 ft long (per S-65EX)
	=	**1,444.4**	BCY	and 10' deep to allow for construction of the underwater seal and
	=	2,166.7	LCY	structural footings. Assume bottom of canal requires blasting to remove rock.
Excavation east and west	=	139,200.0	CF	Assume top of bank is 13.5 ft NGVD and bottom of excavation and
canal banks for installation of	=	**5,155.6**	BCY	bottom of excavation is at -15.5 ft NGVD (Total depth 29'). Assume
	=	7,733.3	LCY	excavation is 160 ft long and extends the bottom of the canal an additional 15' per bank. Assume material is common or rippable as it is the bank of a levee.

Gate weight calculations

3/8" Plate steel	=	15.3	lb/sq ft			
1/2" Plate steel	=	20.4	lb/sq ft			
1" Plate Steel	=	40.8	lb/sq ft			
Gate Skin 3/8" Plate Steel	=	392.0	sq ft	Assume Gate dimensions of 14'x28'		
3/8" Plate stiffeners and seal angles	=	87.0	sq ft	Assume 5 sq ft for seal angles and 82 for stiffeners		
Horizontal C-Channels (1/2")	=	607.0	sq ft	Assume each channel is equivalent to 26"x28' (10 Channels).		
Vertical C-Channels	=	303.0	sq ft	Assume each vertical channel is 26"x14' (10 Channels).		
Pull Pad eyes (1")	=	4.0	sq ft	Assume 4 pad eyes per gate @ 1 sq ft each		
Total 3/8" Plus 10% for misc. items	=	526.9	sq ft	=	8,061.6	lbs
Total 1/2" plus 15% for misc items	=	1,046.5	sq ft	=	21,348.6	lbs
Total 1" steel	=	4.0	sq ft	=	163.2	lbs
lbs/sq ft for 28'x14' gate	=	75.4	lb/sq ft			

Area of single S-622 Gate	=	150.0	sq ft				assumed 3 ft bigger then opening in each direction
Approximate weight of S-622 Gate	=	11,316.3	lb				
Overweight factor for larger gates (0%)	=	11,316.3	LB EA	=	5.7	TON EA	3 Each Needed

Precast Concrete Control Building / Generator Shelter

Shelter square footage	=	315.0	sq ft	Assume Shelter will be 10' tall and have a 8" concrete block partition wall full height. Assume one 4'-4" steel door and one 3'-4" door. Assume 4 3' x 5' Louvers along with a generator radiator
Excavation/backfill for shelter	=	163.3	ECY	Building will be set on grade with 12" capillary water barrier and geotextile fabric and a 12" thick concrete curb around the building
Generator Fuel Tank	=	1,000.0	Gallon	
Fuel Pad dimensions	=	96.0	SF	Assume 8'x12'x12" thick reinforced concrete slab on grade pad.

Gate embeds/seal lengths

Gate Dimensions				
Width	=	15.0	FT	
Height	=	10.0	FT	
Gate well Height	=	42.0	FT	
Gate Well Embed	=	99.0	FT	
Total Embed length	=	297.0	FT	3 gates
Seal Length	=	35.0	FT	seal length is the perimeter of bottom and both sides.
Total Seal length	=	105.0	FT	total of 3 gates
Up and Downstream Bulkhead Slot	=	468.0	FT	6 times vertical plus width of new gate per slot
Bulkheads	=	11,316.3	LB EA	assume same size as gates
number	=	6.0	EA	two per gate needed
Total Length of Imbeds	=	765.0	FT	
Total Weight of Gates and Stop Logs	=	101,847.1	LB	= 50.9 TON
Total Length of Seals Stop Logs and Gates	=	315.0	LF	

Backfill

Backfill around structures	=	5,155.6	ECY	=	5,825.78	LCY	

Railings and ladders

Railing				
Length	=	826.0	FT	assumed 4 time the length of a wing wall and 6 times the width of the structure and twice the length
Height	=	3.5	FT	
Ladders				
Count	=	6.0	EA	assumed ladders on each side of the structure.
Height	=	17.5	FT	average of all three types
total height	=	105.0	FT	

Boat Barrier

Number	=	2.0	EA		
Length each	=	450.0	FT		
Total Length	=	900	FT		

Site Fencing

Length	=	1,000.0	FT		assumed a total of 1000 LF of chain link fencing.
Gates	=	4.0	EA		assumed

SWPPP

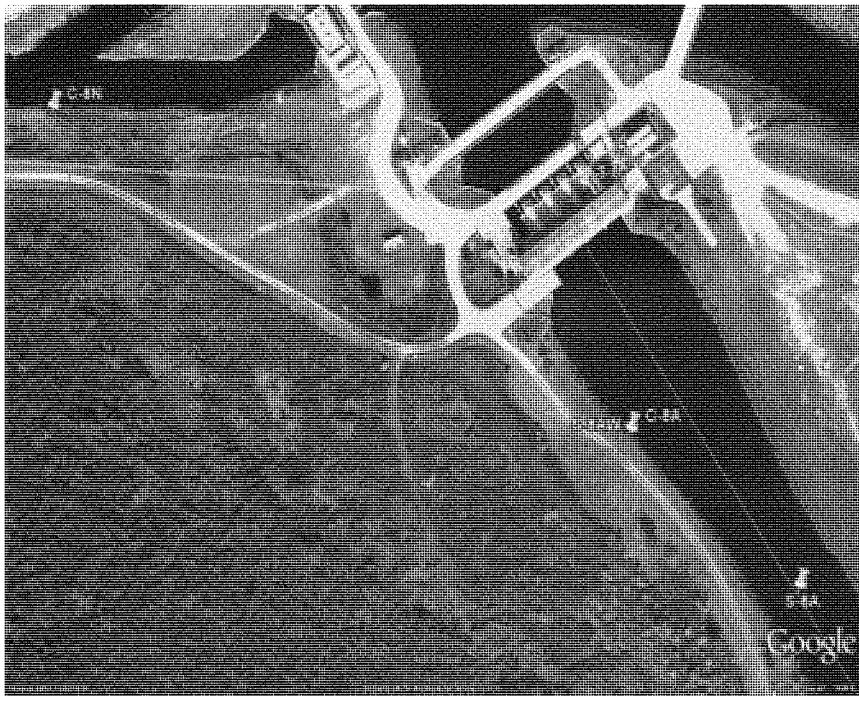
Length	=	-	LF		
Floating Silt Boom	=	2,700.0	LF		assumed 6 times the top width of the canal

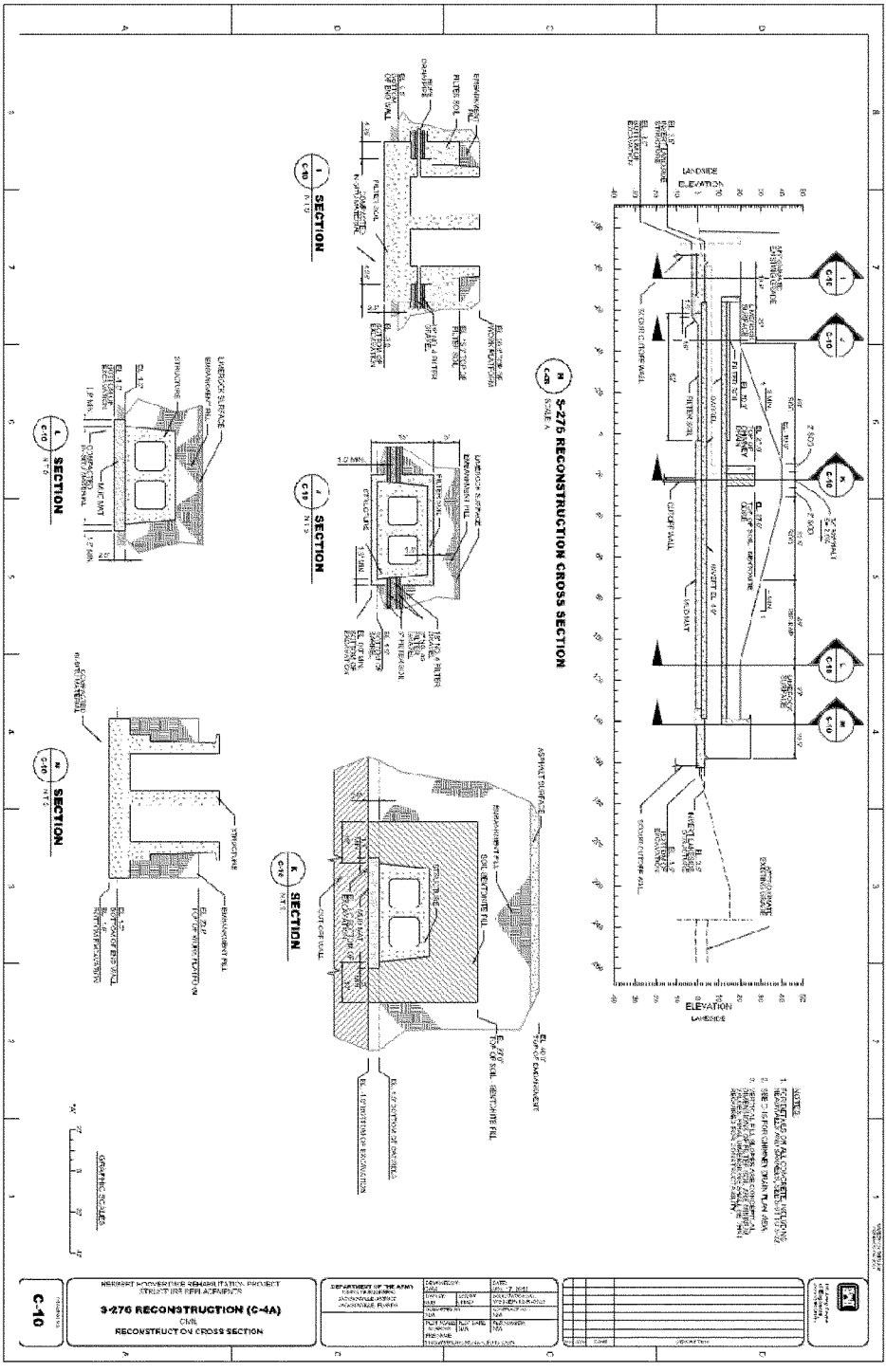
Access road

Length	=	300.0	FT		assumed
Width	=	14.0	FT		assumed
Area	=	4,200.0	SF	= 466.7	SY

Feature of Work:	New (S-8A) PS Gated Culverts with New Canal (3080 CFS and 1020 CF Gated Culvert)
Scope Given:	S-8A new gated culverts to deliver water from the Miami Canal (downstream of S-8, which pulls water from the L-5 Canal) to the L-4 Canal
Reference for Scope Basis:	Engineering Appendix, March 2013 and Annexes A.6.4.1 General Status of Completed and Non-Executed Efforts A.6.5.2 General Status of Completed and Non-Executed Efforts A.2 Recommended Plan
Scope Assumptions:	- Assume two gated Structures similar to S-276 and S-277. - Assume that the size of the 1020 gated culvert is similar to S-628 but upsized. - Assume that the size of the 3080 gated culvert is twice the size of the s-625 structure. - Assume power for both structures will be provided from local power lines located at the existing S-8 pump statior - Assume sequence of work will be such that a two stage cosntruction of the gated culvert in the Miami Canal will b constructed with no diversion canal needed in the Miami Canal. - Assume sequence of work will complete the new structure and canal to the L-4 levee prior to construciton of the 1020 gated culvert in the Miami Canal. - Assume that no diversion canal is needed to construct the gated culvert that will be in the new canal as the culver will be built prior to excavation of the canal. - Assume that the canal will be the same shape as the L-5 Western Canal. - Assume material layering of 1.5 ft of organic material 10 ft of Cap Rock requiring Blasting and the remainder will b interbedded material. -Assume access to the western side of the 1020 Gated culvert will be available by crossing the S-8 pump station an across the 3080 gated culvert.
Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.
Sequence of Work:	General sequence: 3080 CFS Gated Structure, Canal and then the 1020 CFS structure in the Miami Canal. 3080 CFS Gated Structure: - Site survey and stake area of construction. - Install silt fence and maintain as needed. - Excavate and utilize rim ditch dewatering to dewater site. Canal: - Site survey and stake entire length and width of canal. - Install silt fence and maintain as needed. - Clear and grub entire site to remove vegetation and organic materials. Haul to disposal location. - Construct a haul road parallel to the canal. This will be ongoing as needed during construction of the canal. Haul road maintenance will be ongoing during construction of the canal. Assumed same length as the canal will stay in place after construction. Assumed width of 14 ft 1 ft thick. - Excavate material placing on to the haul road and allow draining off excess water. - Load drained material into haul truck and take to processing plant. 1020 CFS Gated Structure: - Site Survey and stake area of construction. - Install silt fence and maintain as needed. - Install sheetpile and dewater working on the eastern side followed by the western half of the gated culvert.
Key Outstanding Questions/Issues:	No Data is provided for the canal and associated levees that will be required. limited data provided for the gated culverts. Concerns with flood protection. Design team has indicated no diversion canal will be needed for the 1020 CFS structure to be placed in the Miami canal if the sequence of construction for other features is accomplished pr to its construction.

Representative Drawings/Photos: S-8A




3-276 RECONSTRUCTION CROSS SECTION
SCALE: N
SECTION
SECTION
SECTION
SECTION
SECTION
LANDSIDE ELEVATION
ELEVATION
LANDSIDE
3-276 RECONSTRUCTION (C-4A)
CIVIL
RECONSTRUCT ON CROSS SECTION
C-10

Feature of Work:	New (S-8A) PS Gated Culverts with New Canal (3080 CFS and 1020 CFS Gated Culvert)

Quantity Take Off:

Gated Culvert 1020 CFS upsized S-628 added an additional culvert

number of culverts	=	3.0	EA						
Miami Canal Plug									
Number	=	2.0	EA						
Length	=	125.0	FT						
Top Width	=	100.0	FT						
Side Slope	=	3.0	:1						
Depth	=	20.0	FT						
Bottom Width	=	220.0	FT						
Volume	=	800,000.0	CF	=	29,629.63	ECY	=	33,481.48	LCY
Remove Canal Plugs									
Volume	=	29,629.6	BCY						
Gated Culvert Excavation									
width	=	57.0	FT		assumed all rippable rock				
depth	=	3.0	FT						
length	=	140.0	FT						
Volume of Ripping	=	23,940.0	CF	=	886.7	BCY	=	1,330.0	LCY
Concrete Culvert Concrete									
Length	=	140.0	FT						
Foundation Concrete									
Bottom Width	=	39.0	FT						
Bottom Thickness	=	2.5	FT						
Volume	=	13,650.0	CF	=	505.6	CY			
Vertical concrete									
Height	=	9.0	FT						
width of walls	=	12.5	FT						
Volume	=	15,750.0	CF	=	583.3	CY			
Elevated Concrete									
Top Width	=	34.5	FT						
Thickness	=	2.5	FT						
Volume	=	12,075.0	CF	=	447.2	CY			
PVC water stops	=	2.0	EA						
Length	=	87.5	LF						
Spacing	=	15.0	FT						
Total Length	=	1,750.0	LF						

Inlet and Outlet Works

Number	=	12.0	EA	assumed intake/outlet are the same assumed 2 per each end gate and bulkhead			
Foundation							
Length	=	8.0	FT				
Depth	=	5.0	FT				
Width	=	57.0	FT				
Volume	=	9,120.0	CF	=	337.8	CY	
Head Walls							
Height	=	25.5	FT				
Thickness	=	3.0	FT				
width	=	45.5	FT				
openings	=	243.0	SF				
volume	=	11,007.0	CF	=	407.7	CY	
End walls							
height	=	24.0	FT				
length	=	100.0	FT	total either inlet or outlet			
thickness	=	2.0	FT				
volume	=	9,600.0	CF	=	355.6	CY	

Misc Metals

Railing	=	358.0	LF				
Ladders	=	6.0	EACH				
height	=	25.5	FT	=	153.0	FT	
Grating	=	400.0	SF per gate	assumed 20 by 20 per gate per end			
TOTAL Grating	=	2,400.0	SF				

Gates IN HHD

Height	=	14.0	FT	*** STAINLESS STEEL for opening 7 by 7
Width	=	10.0	FT	
Weight	=	6,500.0	LB	
Weight Per SF	=	46.4	LB/SF	

NEW GATES

number of gates	=	12.0	EA	assumed 2 on each end 1 gate and one bulkhead.					
Height	=	16.0	FT	assumed 2 ft larger then similar gate					
Width	=	12.0	FT	assumed 2 ft larger then similar gate					
Weight % larger	=	10.0	%	assumed					
Total Weight of gates	=	9,805.7	LB EA	=	117,668.6	LB	=	58.8	TON
Motors	=	12.0	EA						
Gear Reduction	=	12.0	EA						
Actuators	=	12.0	EA						
cable reels	=	12.0	EA						
Imbeds for gate	=	756.0	LF						
Gate Seal Length	=	672.0	LF						

Operations building

size	=	315.0	SF 21 by 15 ft
Electrical	=	NEEDED	
Communications	=	NEEDED	

Cut off walls

Number	=	1.0	EA		Assumed in FEB perimeter Levee				
Soil Bentonite Fill									
Height	=	25.0	FT						
Width	=	59.0	FT						
Thickness	=	8.0	FT						
Volume	=	11,800.0	CF/EA	=	437.0	CY/EA			
Cutoff Wall									
Height	=	35.0	FT						
Width	=	57.0	FT						
Thickness	=	3.0	FT						
Volume	=	5,985.0	CF/EA	=	221.7	CY/EA			
Area	=	1,995.0	SF/EA						

RIP RAP

common both sides									
number of placements	=	2.0	EA		1 each side				
Length	=	20.0	FT						
Width	=	57.0	FT						
thickness	=	4.0	FT						
Volume	=	4,560.0	CF/EA	=	168.9	CY/EA			
Total Volume	=	337.8	ECY	=	540.4	TON			

Backfill

around Culvert	=	**886.7**	ECY	=	1,001.9	LCY			

Removal

Sheet Pile	=	29,629.6	SF						

Boat Barrier

Number	=	2.0	EA						
length	=	160.0	FT EA						
TOTAL length	=	320.0	FT						

SWPPP

Length	=	300.0	FT						
Floating Silt Boom	=	320.0	FT		Assumed same length of Boat Barrier				

Site Fence

Length	=	1,000.0	FT		assumed				
Gates	=	4.0	EA		assumed				

Site Restoration

area	=	4,400.0	SF	=	488.9	SY			

Gated Culvert 3080 Doubled S-625 structure

number of culverts	=	6.0	EA						

Rim Ditch Excavation

Length	=	140.0	ft	Length of excavation					
Width	=	100.0	ft	Bottom width of excavation					
Canal Dimension	=	3ft deep x 3 ft wide							
Ditch volume	=	2,160.0	CF	=	**80.0**	BCY	=	100.0	LCY

Culvert excavation

Length	=	140.0	FT						
Total Depth	=	28.0	FT						
Thickness of Organic	=	1.5	FT						
Thickness of Blasting Cap Rock	=	10.0	FT						
Thickness of Inter-Bedded Material	=	16.5	FT						
Slope1	=	3.0	:1						
Slope2	=	3.0	:1						
Bottom Width	=	100.0	FT						
Top Width	=	268.0	FT						
Cross Section	=	5,152.0	SF						
Cross Section Organic	=	395.3	SF						
Cross Section of Blasting Cap Rock	=	2,290.0	SF						
Cross section of Inter-Bedded Material	=	2,466.8	SF						
Organic Volume	=	55,335.0	CF	=	**2,049.4**	BCY	=	2,561.8	LCY
Blasted Cap Rock Volume	=	320,600.0	CF	=	**11,874.1**	BCY	=	17,811.1	LCY
Inter-Bedded Material Volume	=	69,069.0	CF	=	**2,558.1**	BCY	=	3,837.2	LCY
		TOTAL		=	16,481.6	BCY			

Concrete Culvert Concrete

Length	=	140.0	FT			
Foundation Concrete						
Bottom Width	=	78.0	FT			
Bottom Thickness	=	2.5	FT			
Volume	=	27,300.0	CF	=	1,011.1	CY
Vertical concrete						
Height	=	9.0	FT			
width of walls	=	17.5	FT			
Volume	=	22,050.0	CF	=	816.7	CY
Elevated Concrete						
Top Width	=	69.0	FT			
Thickness	=	2.5	FT			
Volume	=	24,150.0	CF	=	894.4	CY
PVC water stops	=	2.0	EA			
Length	=	161.0	LF			
Spacing	=	15.0	FT			
Total Length	=	3,220.0	LF			

Inlet and Outlet Works

Number	=	24.0	EA				assumed intake/outlet are the same assumed 2 per each end gate and bulkhead
Foundation							
Length	=	8.0	FT				
Depth	=	5.0	FT				
Width	=	78.0	FT				
Volume	=	12,480.0	CF	=	462.2	CY	
Head Walls							
Height	=	25.5	FT				
Thickness	=	3.0	FT				
width	=	66.5	FT				
openings	=	486.0	SF				
volume	=	14,517.0	CF	=	537.7	CY	
End walls							
height	=	24.0	FT				
length	=	100.0	FT				total either inlet or outlet
thickness	=	2.0	FT				
volume	=	9,600.0	CF	=	355.6	CY	

Misc Metals

Railing	=	358.0	LF					
Ladders	=	12.0	EACH					
height	=	25.5	FT	=	306.0	FT		
Grating	=	400.0	SF per gate				assumed 20 by 20 per gate per end	
TOTAL Grating	=	4,800.0	SF					

Gates IN HHD

Height	=	14.0	FT	*** STAINLESS STEEL for opening 7 by 7
Width	=	10.0	FT	
Weight	=	6,500.0	LB	
Weight Per SF	=	46.4	LB/SF	

NEW GATES

number of gates	=	24.0	EA	assumed 2 on each end 1 gate and one bulkhead.						
Height	=	16.0	FT	assumed 2 ft larger then similar gate						
Width	=	12.0	FT	assumed 2 ft larger then similar gate						
Weight % larger	=	10.0	%	assumed						
Total Weight of gates	=	9,805.7	LB EA	=	235,337.1	LB	=	117.7	TON	
Motors	=	24.0	EA							
Gear Reduction	=	24.0	EA							
Actuators	=	24.0	EA							
cable reels	=	24.0	EA							
Imbeds for gate	=	1,512.0	LF							
Gate Seal Length	=	1,344.0	LF							

Operations building

size	=	315.0	SF	21 by 15 ft
Electrical	=	NEEDED		
Communications	=	NEEDED		

Cut off walls

Number	=	1.0	EA	Assumed in FEB perimeter Levee				
Soil Bentonite Fill								
Height	=	25.0	FT					
Width	=	98.0	FT					
Thickness	=	8.0	FT					
Volume	=	19,600.0	CF	=	725.9	CY		
Cutoff Wall								
Height	=	35.0	FT					
Width	=	318.0	FT					
Thickness	=	3.0	FT					
Volume	=	33,390.0	CF/EA	=	1,236.7	CY/EA		
Area	=	11,130.0	SF/EA					

RIP RAP

common both sides									
number of placements	=	2.0	EA		1 each side				
Length	=	20.0	FT						
Width	=	78.0	FT						
thickness	=	4.0	FT						
Volume	=	6,240.0	CF/EA	=	231.1	CY/EA			
Total Volume	=	462.2	ECY	=	739.6	TON			

Backfill

Around Culvert	=	**16,481.6**	ECY	=	18,624.2	LCY			

Removal

Sheet Pile	=	2,160.0	SF						

Boat Barrier

Number	=	2.0	EA						
length	=	160.0	FT EA						
TOTAL length	=	320.0	FT						

SWPPP

Length	=	100.0	FT						

Site Fence

Gates	=	4.0	EA		assumed				

Site Restoration

Area	=	4,400.0	SF	=	488.9	SY			

L-4 Connector Canal

Excavate Canal

Length	=	1,000.0	FT						
Total Depth	=	20.0	FT						
Thickness of Organic	=	1.5	FT						
Thickness of Blasting Cap Rock	=	10.0	FT						
Thickness of Inter-Bedded Material	=	8.5	FT						
Slope2	=	1.5	:1						
Bottom Width	=	100.0	FT						
Top Width	=	160.0	FT						
Cross Section	=	2,600.0	SF						
Cross Section Organic	=	236.6	SF						
Cross Section Blasting Cap Rock	=	1,405.0	SF						
Cross section of Inter-Bedded Material	=	958.4	SF						
Surface Area of Canal	=	160,000.0	SF	=	3.7	ACRE			
Organic Volume	=	236,625.0	CF	=	**8,763.9**	BCY	=	10,954.9	LCY
Blasted Cap Rock Volume	=	1,405,000.0	CF	=	**52,037.0**	BCY	=	78,055.6	LCY
Inter-Bedded Material Volume	=	958,375.0	CF	=	**35,495.4**	BCY	=	53,243.1	LCY

Haul Road

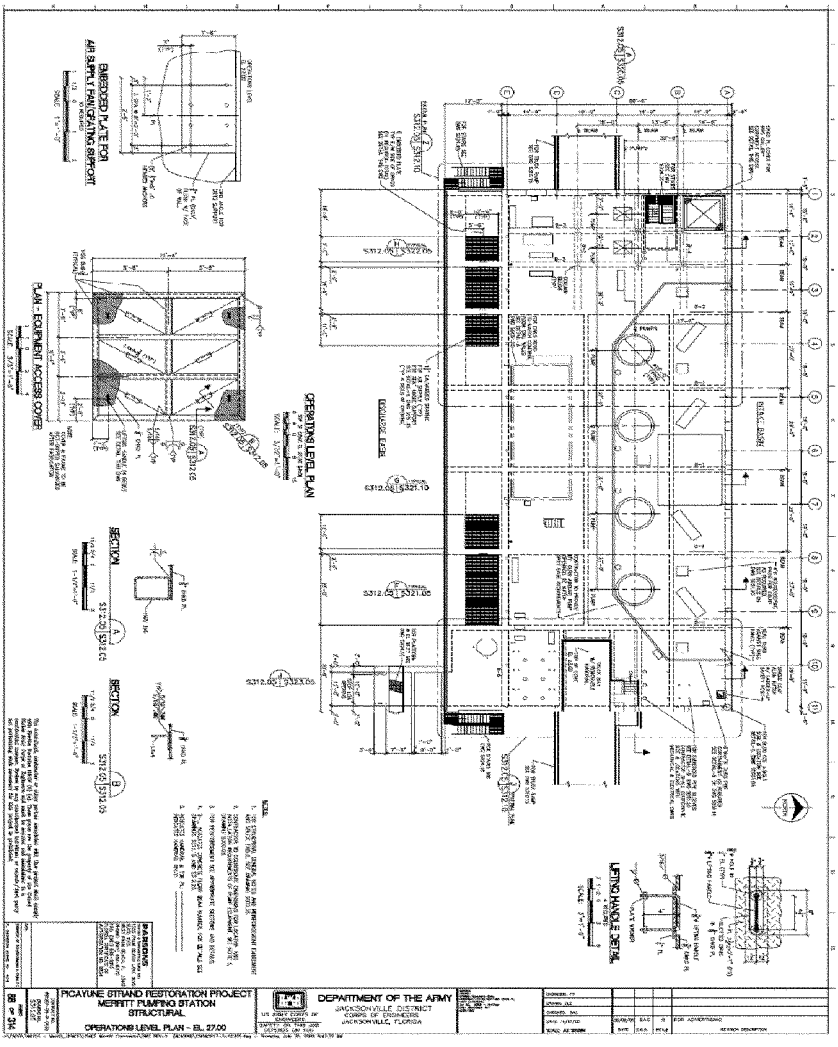
Length	=	1,000.0	FT		
width	=	14.0	FT		
depth	=	1.0	FT		
Area	=	1,555.6	SY		
volume	=	518.5	ECY		

SWPPP

Silt Fence	=	2,000.0	FT	
Floating Silt Boom	=	480.0	FT	Assumed 3 times the top width of the canal

Feature of Work:	S-630 Pump Station 360 CFS in the L-4 Canal
Scope Given:	S-630 is a 200 cfs pump station to maintain Seminole Tribe water supply deliveries west of the L-4 Canal
Reference for Scope Basis:	Engineering Appendix, March 2013 and Annexes A.2 Recommended Plan A.4.1.2 South of Redline A.6.1.5 Utility Relocation A.6.3.2.1.4 Water Control Structure A.6.3.2.1.4.3 Pump Stations A.6.3.3.2.1.4 Pump Stations A.6.3.4.2 Hydraulics and Hydrology Lowering Risk in Design A.6.5.3 Pumping Station S-630
Scope Assumptions:	Scope Assumptions: - Assume similar to structure Pump Station 357. - Assume given dimensions in the engineering appendix govern over provided design documents for similar structu if no dimensions are given in the engineering appendix all dimensions will come from the similar structure. - Assume there will be a total of four 90 cfs electric pumps. - Assume discharge of pumps will be directed in line to the L-4 canal via 48" pipes discharging directly onto the discharge apron. - Assume the discharge structure will consist of a concrete headwall full height of the canal 30 ft wide 18 inch thick reinforced concrete, 20'x30' apron 18 inch thick reinforced concrete, wing walls extending 30ft up and downstrean of the discharge point sloping from full height of the canal to 18 inch thick reinforced concrete and riprap lining 13 ft beyond the concrete apron. - Assume the excavation will extend 3 feet below the L-4 canal bottom elevation. The pump station will require removal 3ft inter-bedded materiarl for removal to allow for foundation construction. - Assume pump station will be constructed of reinforced concrete below grade and a combination of cast-in-place columns and reinforced CMU walls. . - Assume a fuel pad will be required for storage tanks for the diesel pump and the diesel generator, assumed size o 20' by 20' 1 feet thick reinforced concrete. -Assume Power provided from local utilities approximately 800 ft from site. - Assume L-4 dimensions are similar to L-5 canal. Depth is 17 ft, side slopes are 1:5. Top width is assumed to be 85 resulting in a calculated bottom width of 39 ft. -Assume a temporary 200 CFS pump will be utilized to pass water around the feature in lieu of a bypass canal. - Assume intake will require driven piers and suction screen. - Assume 900 LF of 48" discharge piping. - Assume pump will be set on a 12'x12' 1' thick concrete slab and the suction and discharge piping will be containe by piers driven into the canal and supported every 25 ft along the length of pipe. Assume the pipe will be run alon the top of the L-4 levee.
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.
Sequence of Work:	-Site Survey and stake canal for excavation -Install sheet pile/cofferdam up and downstream of structure. -Assume pumping will be required 24/7. - Install silt fence and maintain as needed. -Maintenance of haul route will be ongoing of existing route. -Placement of Headwall foundation structures along with 2 bay pump station to include support facilities. -Backfill around new structure back to the existing elevation and restoration of the access road.
Key Outstanding Questions/Issues:	

Representative Drawings/Photos: S-630



Feature of Work: S-630 Pump Station 360 CFS in the L-4 Canal

Quantity Take Off:

S-630 Pump Station Excavation.

Length	=	80.0	FT							Assume 50 ft to allow for footprint of pump station
Total Depth	=	8.0	FT							Assume Channel depth is 17' with an additional 8' of over excavation for structure.
Thickness of Organic	=	1.0	FT							
Thickness of Cap Rock Material	=	7.0	FT							
Slope1	=	-	:1							Excavation is interior to the sheet piling
Slope2	=	-	:1							
Bottom Width	=	45.0	FT							Assume 100 ft to allow for footprint of Pump Station
Top Width	=	45.0	FT							
Cross Section	=	360.0	SF							
Cross Section Pete	=	45.0	SF							
Cross Section cap Rock Material	=	315.0	SF							
Surface Area of Canal	=	3,600.0	SF	=	0.1	ACRE				
Pete Volume	=	3,600.0	CF	=	133.3	BCY	=	166.7	LCY	
Cap Rock Volume	=	25,200.0	CF	=	933.3	BCY	=	1,400.0	LCY	

Care and Diversion of Water

Construction Sequence:

1 ***Construct perimeter concrete ring beam and rock anchors.
2 Place Sheet piling and connect piling to concrete ring beam. Excavate. Assume sheet pile length of 36 ft
3 Install rock anchors for concrete seal slab. Anchor length 17'-6" slab rock anchor.
4 Place Concrete Seal slab. 6'-0" thick and dimensions of sheet pile
5 Dewater cofferdam and prepare top of concrete base mat slab
6 Place concrete walls to elevation 9'-0" at pump structure monolith prior to abandoning or removing in place cofferdam sheet piles. Remove ring beams in inlet and outlet.
7 install lateral bracing for walls.
8 Construct service bridge slab. Remainder of walls and operating floor slab.
9 Install sheet pile wing walls.

*** May have to utilize a sheet pile setup similar to Herbert Hoover Dike Culvert construction with I beam piers driven in lieu of concrete ring beam.

# of pump station Bays	=	4.0			
Cofferdam width per pump station bay	=	15.0	ft		Assume Per S-101
Total width length	=	60.0	ft		
Length (Up and downstream) of Cofferdam	=	80.0	ft		Assume per S-101
Total perimeter length (length of sheet pile/ring beam)	=	280.0	ft		
Area of Cofferdam sheet pile to rer	=	9,600.0	SF		
Area of cofferdam to be removed	=	7,200.0	SF		
Length of Sheet pile to Be utilized as wing wall	=	186.0	ft		
Volume of ring beam (Reinforced Concrete)	=	65.7	CY		Per detail S-103
# of 54' ring beam anchors @ 10' OC	=	28	ea		Per detail S-101
*** Number of I beam piers	=	47	ea		Assume I beams 6' OC around perimeter of sheet pile and tied to sheet pile
# of 17'-6" uplift slab rock anchors	=	48	ea		
Volume of Concrete seal/uplift slab	=	1,066.7	CY		Assume 6' thick

Backfill around structure

Volume of single side	=	40,800.0	CF
	=	1,511.1	ECY
Total Volume both sides	=	3,022.2	ECY

WINGWALLS Assumed approach wing walls similar to downstream wing wall plan from S-65EX-1 with anchor walls. Construction will consist of 60 ft deep driven sheet pile with a 2'x2' concrete pile cap. The anchor walls will be 1 ft thick reinforced concrete. Concrete anchor wall dimensions will match wing wall dimensions. The wing wall and concrete anchor wall will be connected by #10 all thread grade 70. A C8x18.75 channel will be attached to the back of the wing wall where the anchors will be attached to.

Number	=	4.0	Each
Length each wall	=	62.5	FT
Depth 1	=	37.0	FT
Depth 2	=	16.0	FT
area of sheet pile	=	6,625.0	SF
Pile Cap			
height	=	2.0	FT
width	=	2.0	FT
volume	=	37.0	CY
Rod length	=	60.0	FT
spacing	=	4.0	FT
number of rods	=	63.0	EA
Anchor Walls			
height	=	8.0	FT
thickness	=	1.0	FT
length	=	250.0	FT
volume	=	74.1	CY

Concrete Volumes for Pump Station Building and

Width of each Bay	=	15.00	ft	Assumed per similar PS-357
Length of Operating Floor	=	45.0	ft	
Width of Operating Floor	=	60.0	ft	
				Total Elevated Flatwork = 947.2
Horizontal concrete volume	=	711.1	CY	
Vertical Concrete	=	720.0	CY	
Service Bridge Elevated Flatwork	=	711.1	CY	
Operating Floor (Elevated Flatwork	=	208.3	CY	
Elevated Vertical Work (Operating floor to service bridge)	=	27.8	CY	
SF of Generator, Electric and Office/Control Room	=	900.0	SF	Assume Generator room. Electric Room and Office control room is 20ftx39ft
Loading Truck Ramp (horizontal Concrete)	=	4,903.0	SF	= 272.4 CY Assumed From Merritt Pump Station
Volume of Concrete for Gen, Elec and Office room (Slab on grade)	=	55.6	CY	Assume 18" thick
Assume 10 18"x18"x26' tall Columns	=	21.7	CY	
Tilt Up 7-1/2" Thick Precast Panels	=	21,072.0	SF	Assume Similar to Merritt Pump Station
CMU Wall Dimensions (Exterior Surface Area of CMU)	=	8,400.0	SF	
Roof 32" Double tee units 56 ft long required	=	8	each	
Intake Basin Concrete	=	89	CY	
Discharge Basin Concrete Apron	=	133.3	CY	Assume 36" thick concrete
Stone Protection Riprap discharge	=	1,688.9	CY	Assume 5 ft thick layer of riprap lining the L-4 canal upstream 60 ft and downstream 60 ft.
Stone Protection inlet	=	1,000.0	CY	Assume 36" thick layer of riprap lining the sides and bottom for 150' upstream
Total Riprap	=	2,688.9		
Trash Rack Surface Area (total)	=	1,680.0	SF	Assume Trash rake is 28 ft tall and covers the width of the operating floor each individual covers the width of the bays (14ft).

Roll Up Garage Door	=	168.0	SF	Assume Roll up garage door 12'x14'
# of Doors	=	4.0	ea	Assume 1 set of double doors and two other doors
# louver openings	=	8.0	ea	Assume 8 louver openings 7'-4" square
Overhead Crane	=	2.0	ea	Assume 2 overhead cranes @ 25 tons each
Power Line Connection	=	1,500.0	LF	Assume power available 1500 lf from site
Septic tank system	=	1.0	ea	Assume 1 septic tank system
Potable water	=	1.0	ea	Assume 1 potable water well will be required
Generator Fuel Tank	=	2000 Gallon	ea	Assume two 2000 gallon fuel tanks required
Fuel Pad dimensions	=	400.0	SF	Assume two 20'x20'x1' thick reinforced concrete slab on grade pad.
		14.8	CY	

Discharge Piping

48" discharge pipe	=	50.0	LF/ea	Assume Pumps will have a 48" Discharge Piping
Concrete Encasement	=	279.3	CY	Assume 2 ft of concrete to encase piping
Floor Grating	=	784.0	SF	Assume 14' x14' ft wide for each pump bay.
Ladders	=	120.0	VLF	Assume 30 ft per pump bay
Railings	=	680.0	LF	Assume a handrail on the up and downstream side and one a width of the operating floor, around each bay, exterior stair tower, basin wall platform, interior stair tower, operations plan handrail and the recirculation channel platform.
Haul road length	=	17,731.0	FT	Assume length of road for maintenance
Haul road width	=	14.0		
Haul road thickness	=	1.0	FT	
				SF = 27,581.6 see
Area	=	248,234.0		
Chain link Fence	=	2,280.0	LF	Assume Similar to Merritt Pump Station
Silt Fence	=	3,700.0	LF	Assume similar to Merritt Pump Station
Silt Boom	=	1,000.0	LF	

Bypass Pumping

Assume 200 CFS diesel driven pump with 48" discharge

48" Discharge Pipe length	=	900	LF	
# of 50 ft piers	=	44	ea	Assume 4 piers at the suction and 4 at the discharge with 2 piers every 25 ft along the length of pipe. The suction and discharge piers will be driven by barge.
Concrete Slab for pump and fuel	=	5.333333333	CY	Assume 12'x12'x1' slab

Feature of Work:	Levee Removal L-4 Interior Levee

Scope Given:	The slopes shall be cut to a shallower or equal angle than currently that of the original design levee side slopes of 1V:3H. A riprap blanket with bedding may be needed on each cut face depending on design flow velocities through the gap which will be determined during the design phase.

Reference for Scope Basis:	Engineering Appendix dated March 2013 A.7.2 GEOTECHNICAL DESIGN, Paragraph L-4 Degrade Annex C-2 Table A-1

Scope Assumptions:	- Assume all levee material will be reusable - Assume that all material coming from the levee will need processing prior to reuse as backfill. - Assume levee crown width as 10 ft, assume height of 6 ft, assume side slopes of 2.5:1.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

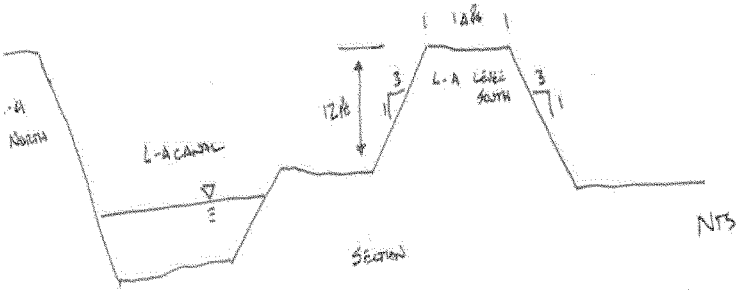
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope and assumptions were documented and sent to the design team for review. After reaching consensus on the scope and major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

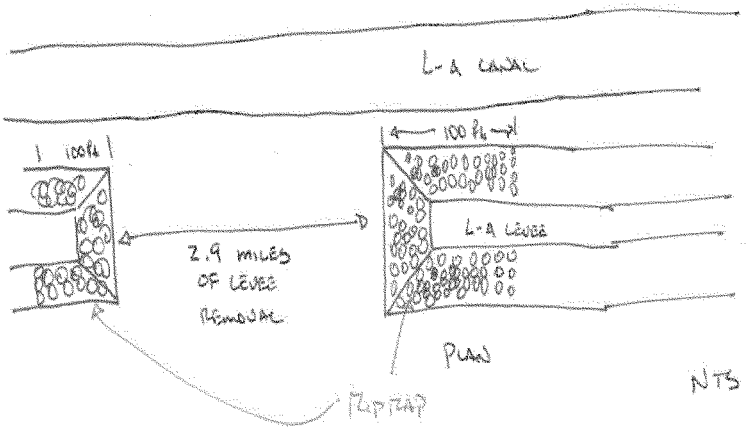
Sequence of Work:	- Survey site and stake entire length of canal. - Install floating turbidity boom and silt fence along the entire length of the canal. Floating turbidity boom and silt fence maintenance will be ongoing during construction of the canal. Maintenance of existing levee access road will be on going throughout construction. - Clear and grub entire site to remove vegetation and organic materials. - Excavate levee, process and place materials - Place Riprap on ends of excavated levee.

Key Outstanding Questions/Issues:	L-4 Plates are referenced in Annex C-2 but none are present. No Data on current levee is given. Only reference to length to be removed is in Table A-1.

Representative Drawings/Photos: L-4 Levee Removal

L-4 REMOVAL





Feature of Work: Levee Removal L-4 Interior Levee

Quantity Take Off:

Levee Removal

Length	=	15312	FT			2.9	Miles =	15312	FT	
Height	=	6	FT							
Slope1	=	2.5	:1							
Slope2	=	2.5	:1							
Top width	=	10	FT							
Bottom Width	=	40	FT							
Cross Section	=	150.0	SF							
Surface Area of Levee	=	977,696.4	SF	=	22.4	ACRE				
base area of levee	=	612,480.0	SF	=	68,053.3	SY	=	14.1	Acre	
side slopes of levee	=	824,576.4	SF	=	91,619.6	SY	=	18.9	Acre	
roadway area	=	153,120.0	SF	=	17,013.3	SY	=	3.5	Acre	
Total Volume	=	2,296,800.0	CF	=	85,066.7	BCY	=	127,600.0	LCY	

Feature of Work:	Miami Canal Backfill

Scope Given:	The Miami Canal is cut nearly perpendicular to topographical contours through WCA-3A. As such, water is "short-circuited" through the wetlands versus historic shallow sheet flow across the floodplain. To investigate how backfilling the canal may impact flow, a 2-dimenisional model using the Adaptive Hydraulics Modeling (AdH) computing software was constructed and simulation of various "plug" or backfill lengths were made with various configurations. It was found that a plug length of simple configuration, e.g. no berm lateral extensions into the marsh, of 4,000 feet caused canal flows to leave the canal, enter the marsh, and continue southerly as sheet flow. Since the design backfill is of longer length, there is little risk that the planned feature will not work as intended.

Reference for Scope Basis:	Engineering Appendix dated March 2013 A.7.2 GEOTECHNICAL DESIGN, Paragraph Backfill Miami Canal Annex C-2 Table A-1

Scope Assumptions:	- A cut fill analysis will be performed on the material. Material will come from the following in order: L-4 Degrade, S Degrade and the remainder from surpluses from the FEB (average haul distance for FEB Material is 22 miles one way or 44 mile round trip). - Assumed side slopes of Miami canal 1:1.5 same as new design for L-5 east and west canal. - Assumed width of canal constant at 80 ft. - Assumed depth of the Miami canal 18 ft leading to a bottom width of 26 ft. - Assumed all material will not need to be processed prior to placement. - Assumed spoil mound material is all degraded lime stone and lime stone. - Assumed top 0.5 ft is unsuitable for backfilling the Miami canal. - Assumed dimensions of spoil mounds length 400 ft width 100 ft measured from Google earth. Average height above 10.0 ft elevation is 5 ft. - Assumed spoil mounds will be cleared and grubbed. - Assumed gaps between mounds are at 8.5 ft in elevation 100 FT in length and full width of the spoil mounds. - Assumed removal of S-339 will not be required.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

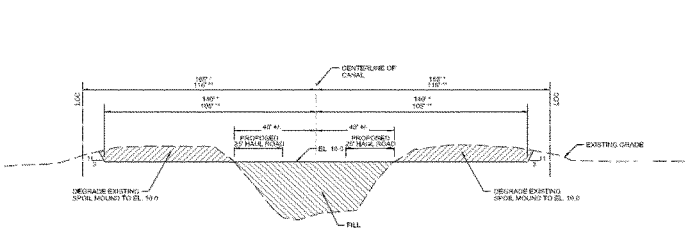
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope and assumptions were documented and sent to the design team for review. After reaching consensus on the scope and major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	- Survey site and stake entire length of canal. - Install floating turbidity boom and silt fence along the entire length of the canal. Floating turbidity boom and silt fence maintenance will be ongoing during construction of the canal. - Clear and grub entire site to remove vegetation and organic materials. Retained for Tree Mounds - Build access road from spoil mound to spoil mound first 1.5 miles on east bank. Utilize spoil mound material for backfill of gaps between mounds. Maintenance of haul road will be on going throughout construction. After a suitable plug for driving haul trucks has been constructed across the Miami canal build a haul road the same manor on the west bank. - Degrade Existing spoil mounds into Miami canal. - Haul fill in from other projects on site after processing all material. Haul in the remainder of the fill from offsite sources. - Backfill material into the Miami Canal. Compaction will be required after the fill has covered the water surface elevation. - Removal of haul road.

Key Outstanding Questions/Issues:	

Representative Drawings/Photos: Miami Canal



TYPICAL SECTION
CANAL BACKFILL AND SPOIL MOUND DEGRADE

SCALE: N.T.S.

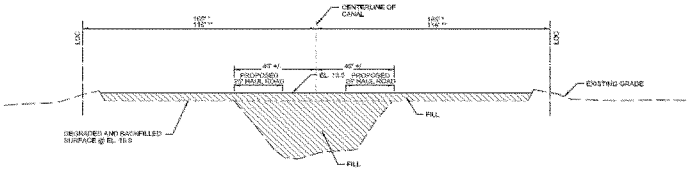
* STATION 470400 TO STATION 477400
** STATION 477400 TO STATION 505400

LOC - LIMITS OF CONSTRUCTION
STA - STATION FOR MIAMI CANAL

INTENT IS TO MAINTAIN A BUFFER FROM EDGES OF SPOIL MOUND - 25 FEET SET AS L

PROVIDED 1 MILE SPACING BETWEEN EARTHEN MOUND ABOVE 10' NAVD, ALONG THE MIAMI CANAL

PROPOSED EARTHEN MOUND DIMENSION ARE 260x200 * & 210x150 ** FEET ALONG CAN



Feature of Work: Miami Canal Backfill

Quantity Take Off:

Sequence of Work

Assume existing spoil mounds will be cleared and grubbed starting from the north working south on both sides of the Miami Canal. The spoil mounds will be degraded on both sides to allow for construction of a haul road from the S-8 area south to the south terminus of the canal backfill. Material from the degraded levees will be moved into the Miami Canal and additional processed material will be brought from the soil processing site in the vicinity of S-8. Backfill of the canal will progress from the south heading north and the construction of the Tree islands will be constructed concurrently with the backfill project. The haul road and site restoration will occur in backfilled sections as work progresses north leaving 1 14 ft wide haul road for the tree mound construction. S-339 structure will be abandoned in place and backfilled around.

CANAL

Length	=	78,144.0	FT		14.8	Miles	=	78,144.0	FT
Top width	=	80.0	FT						
Side slopes	=	1.5	:1						
Depth	=	18.0	FT						
Bottom Width	=	26.0	FT						
Volume of Fill	=	74,549,376.0	CF	=	2,761,088	ECY	=	3,451,360.00	LCY
								3,666,582.22	

SPOIL MOUNDS

Length	=	400.0	FT							
Spacing	=	125.0	FT							
Number of mounds per side	=	149.0	EA							0.582676587
Total Number of Mounds	=	298.0								
Width of mound	=	100.0	FT							
Depth of mound	=	3.5	FT	Assume 1.5 ft of spoil mound will be unaccessible to to settlement						
unsuitable	=	0.5	FT							
Area to be Stripped	=	14,900,000.0	SF	=	342.06	acres				
Volume of Usable	=	5,960,000.0	CF	=	220,740.74	BCY	=	275,925.93	LCY	
Usable	=	3.0	FT							
Volume of Mounds	=	35,760,000.0	CF	=	1,324,444	BCY	=	1,655,555.56	LCY	

Fill Between Mounds For Haul Roads

Length	=	100.0	FT						
width	=	100.0	FT						
Depth	=	1.5	FT						
Volume of fill	=	4,470,000.0	CF	=	165,556	ECY	=	215,222.22	LCY

Total Volume available for fill from Spoil Mounds

Assume Material needed for fill between mounds for haul roads is wasted

Volume	=	1,152,266.7	ECY	=	1,440,333	LCY
Additional Volume Needed	=	1,608,821.3	ECY	=	2,011,026.67	LCY

SWPPP

Silt Fence	=	156,288.0	LF	Assume silt fence installed along both sides of canal entire length
Silt Boom	=	4,736.0	LF	Assume silt boom installed across the width of the canal every 0.25 miles.

Haul Road

Haul road length	=	156,288.0	FT			
Haul road width	=	14.0	FT			
Haul road thickness	=	1.0	FT			
Area of Haul Road	=	2,188,032.0	SF	=	243,114.7	SY

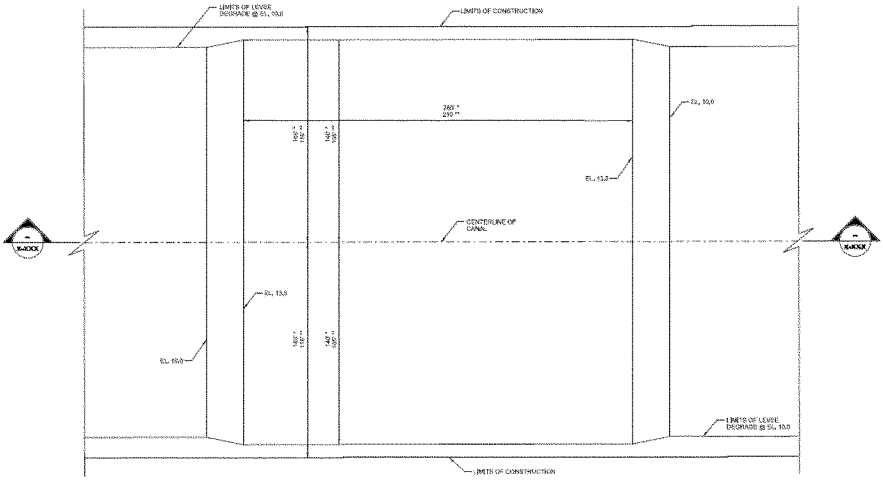
Site Restoration

Area of disturbed earth	=	25,787,520.0	SF	=	2,865,280	SY
Site restoration less Tree mounds	=	2,621,767.1				

Feature of Work:	Tree Islands Mounds Miami Canal

Scope Given:	Degrade spoil mounds North of S-339 and hybrid (leaving some created mounds in place) approach South of S-339 Create Tree Island Mounds every 1 mile north S-339 and hybrid configuration south of S-339.
Reference for Scope Basis:	Engineering Appendix dated March 2013 A.12 Engineering Plates
Scope Assumptions:	- Assumed that the earthen mounds referenced in the C-2 Annex are actually the Tree mounds referenced in the Engineering appendix. - Assumed that half the mounds are 280 ft by 280 ft and the other half are 210 ft by 210 ft. - Assumed that 14 mounds will be required in the 13.5 miles of the Miami canal backfill. - Assumed that the top 1 ft of material is organic material from previous excavations to promote plant growth. - assumed that the removal of the haul road will be completed in the backfilling of the Miami canal even though th haul roads will be utilized during this construction.
Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.
Sequence of Work:	- Survey and stake Tree island locations. - Install floating turbidity booms and silt fence around the affected areas. Floating turbidity booms and silt fence maintenance will be on going throughout construction of the tree islands. - Build tree island mounds on top of backfilled canal to elevation 13.5. - Plant tree island mounds with native trees and grasses.
Key Outstanding Questions/Issues:	

Representative Drawings/Photos:



TYPICAL SECTION - EARTHEN MOUND

SCALE: N.T.S.
STA. XX+XX.XX
STA. XX+XX.XX
STA. XX+XX.XX
STA. XX+XX.XX
STA. XX+XX.XX
STA. XX+XX.XX
STA. XX+XX.XX
STA. XX+XX.XX
STA. XX+XX.XX



EARTHEN MOUND SECTION

SCALE: N.T.S.

Feature of Work: Tree Island Mounds Miami Canal

Quantity Take Off:

Qty of Islands	=	14.0	EA					
small islands	=	7.0	EA					
large islands	=	7.0	EA					
height of island	=	3.5	FT					
length of small island	=	210.0	FT					
width of small island	=	210.0	FT					
length of large island	=	280.0	FT					
width of large island	=	280.0	FT					
End Slope	=	10.0	:1					
volume of small island	=	154,472.5	CF	=	5,721.2	ECY		
Volume of Large Island	=	274,522.5	CF	=	10,167.5	ECY		
Total volume	=	3,002,965.0	CF	=	111,220.9	ECY	= 125,679.65	LCY
Area of islands	=	1,097,600.0	SF	=	25.2	ACRE		
				=	121,955.6	SY		

SWPPP

Perimeter of Tree Islands	=	14,280	LF	

Haul Road

Area of Haul Road	=	121,557.33	SY	Assume 14 ft wide and the length of the Miami Canal Backfilled section
Total Area for Site Restoration	=	243,512.9	SY	
Trees	=	7547	EA	assumed 150 trees per acre 3 gallon potted trees. Per e-mail from Ehlinger, Gretchen S SAJ dated Thursday, May 30, 2013 11:45 AM

Feature of Work:	Canal 500 CFS Remnant L-5 Canal East

Scope Given:	The CEPP modifications to the eastern remnant L-5 Canal will accommodate 500 cfs, and the CEPP modifications to the west L-5 Canal will accommodate 3,000 cfs. The design HW and TW for the improved canal were 12.00 ft NGVD and 10.00 ft NGVD, respectively. From Table A-20 length 31,000 ft, side slope 1:1.5 bottom width 50 FT average depth 14.6 ft.

Reference for Scope Basis:	Engineering Appendix dated March 2013 A.6.3.3.2.1.3 Canals Table A-20 and A-22

Scope Assumptions:	- Assume 1.5 ft of Organic Material, 10 ft of Limestone Cap Rock that will require blasting and Inter-Bedded Materi will be the remainder of the excavation - assumed bottom width references total width of canal after widening. - Assumed average top width of canal is currently 58 FT measured multiple points on Google earth. Assumed curre canal has same side slopes of 1 to 1.5 with average depth of ~15.25 ft from Table A-22 leads to bottom width of ~12.25 ft. - Assume Material will be transported to the Miami Canal for Backfill. (Average of 19 mile one way haul)

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

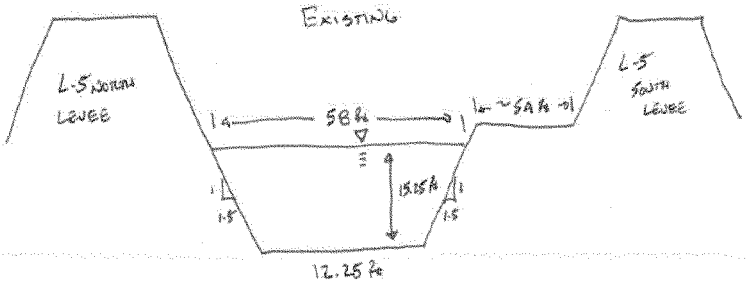
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope and assumptions were documented and sent to the design team for review. After reaching consensus on the scope and major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	'- Survey site and stake entire length of canal. - Install floating turbidity boom along the entire length of the canal. Floating turbidity boom maintenance will be ongoing during construction of the canal. - Clear and grub entire site to remove vegetation and organic materials. Haul to disposal location. - Utilize the southern levee on the L-5 Canal as a haul road. Haul road maintenance will be ongoing during construction of the canal. Assumed width of 14 ft 1 ft thick. - Excavate Material and haul to Miami Canal Backfill.

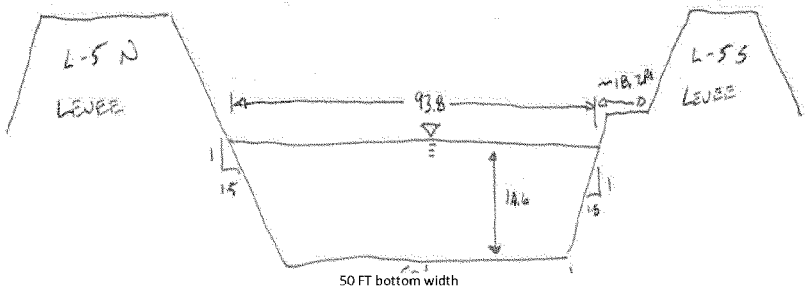
Key Outstanding Questions/Issues:	Unknown current dimensions depth, width, and side slopes of existing canal and distances between levees.

Representative Drawings/Photos: L-5 East Canal

L-5 EAST IMPROVEMENTS



AFTER IMPROVEMENTS



Feature of Work: Canal 500 CFS Remnant L-5 Canal East

Quantity Take Off:

Length	=	31,000.0	Ft				
Width	=	37.8	Ft				
Depth	=	14.6	Ft				
Depth of Organic	=	1.5	FT				
Depth of Blasted Cap Rock	=	10.0	FT				
Depth of Inter-Bedded Material	=	3.1	FT				
Volume of Organic	=	1,755,375.0	CF	=	65,013.9 BCY	=	81,267 LCY
Volume of Blasted Cap Rock	=	11,702,500.0	CF	=	433,425.9 BCY	=	650,139 LCY
Volume of Inter-Bedded Material	=	3,627,775.0	CF	=	134,362.0 BCY	=	201,543 LCY
Surface Area of Excavation	=	1,170,250.0	SF	=	26.9 ACRE		
Silt Boom	=	9,300.0	LF		Assume Floating Boom installed every 500 ft across the canal.		
Haul Road Maintenance	=	26,009	SY				

Feature of Work:	Canal 3000 CFS L-5 Canal West

Scope Given:	The CEPP modifications to the eastern remnant L-5 Canal will accommodate 500 cfs, and the CEPP modifications to the west L-5 Canal will accommodate 3,000 cfs. The design HW and TW for the improved canal were 12.00 ft NGVD and 10.00 ft NGVD, respectively. From Table A-21 length 45,000 ft, side slope 1:1.5 bottom width 100 FT average depth 16.0 ft.

Reference for Scope Basis:	Engineering Appendix dated March 2013 A.6.3.3.2.1.3 Canals Table A-21 and A-22

Scope Assumptions:	- Assume 1.5 ft of Organic Material, 10 ft of Limestone Cap Rock that will require blasting and Inter-Bedded Materi will be the remainder of the excavation - Assumed bottom width references total width of canal after widening. - Assumed average top width of canal is currently 120 FT measured multiple points on Google earth. Assumed current canal has same side slopes of 1 to 1.5 with average depth of ~17 ft from Table A-22 leads to bottom width ~69 ft. - Assume Material will be transported to the Miami Canal for Backfill. (Average of 13 mile one way haul)

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope and assumptions were documented and sent to the design team for review. After reaching consensus on the scope and major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

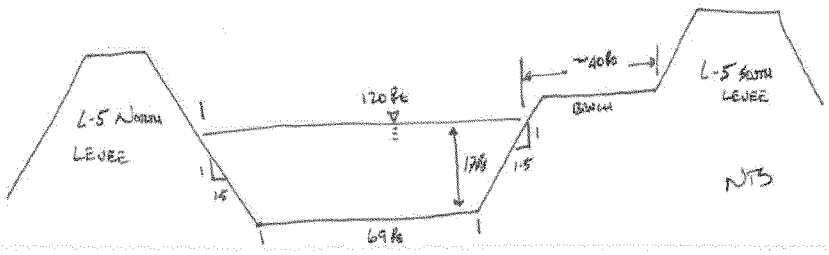
Sequence of Work:	- Survey site and stake entire length of canal. - Install floating turbidity boom along the entire length of the canal. Floating turbidity boom maintenance will be ongoing during construction of the canal. - Clear and grub entire site to remove vegetation and organic materials. Haul to disposal location. - Utilize the southern levee on the L-5 Canal as a haul road. Haul road maintenance will be ongoing during construction of the canal. Assumed width of 14 ft 1 ft thick. - Excavate Material and haul to Miami Canal Backfill.

Key Outstanding Questions/Issues:	Unknown current dimensions depth, width, and side slopes of existing canal and distances between levees.

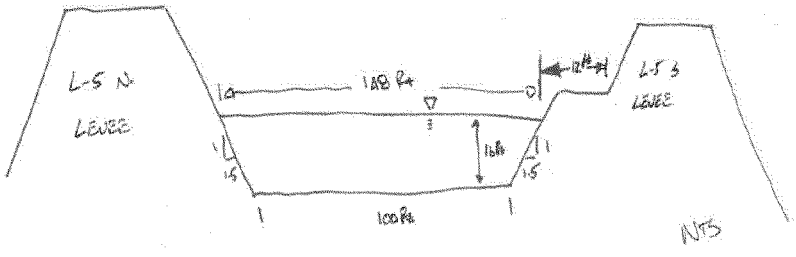
Representative Drawings/Photos: L-5 West Canal

L-5 WEST IMPROVEMENTS

EXISTING



AFTER IMPROVEMENTS



Feature of Work: Canal 3000 CFS L-5 Canal West

Quantity Take Off:

Length	=	45,000.0	Ft				
Width	=	31.0	Ft				
Depth	=	16.0	Ft				
Depth of Organic	=	1.5	FT				
Depth of Blasted Cap Rock	=	10.0	FT				
Depth of Inter-Bedded Material	=	4.5	FT				
Volume of Organic	=	2,092,500.0	CF	=	77,500.0 BCY	=	96,875 LCY
Volume of Blasted Cap Rock	=	13,950,000.0	CF	=	516,666.7 BCY	=	775,000 LCY
'olume of Inter-Bedded Material	=	6,277,500.0	CF	=	232,500.0 BCY	=	348,750 LCY
					826,666.7 BCY		
Surface Area of Excavation	=	1,395,000.0	SF	=	32.0 ACRE		
Silt Boom	=	13,500.0	LF		Assume Floating Boom installed every 500 ft across the canal.		
Haul Road Maintenar	=	17,796	SY				

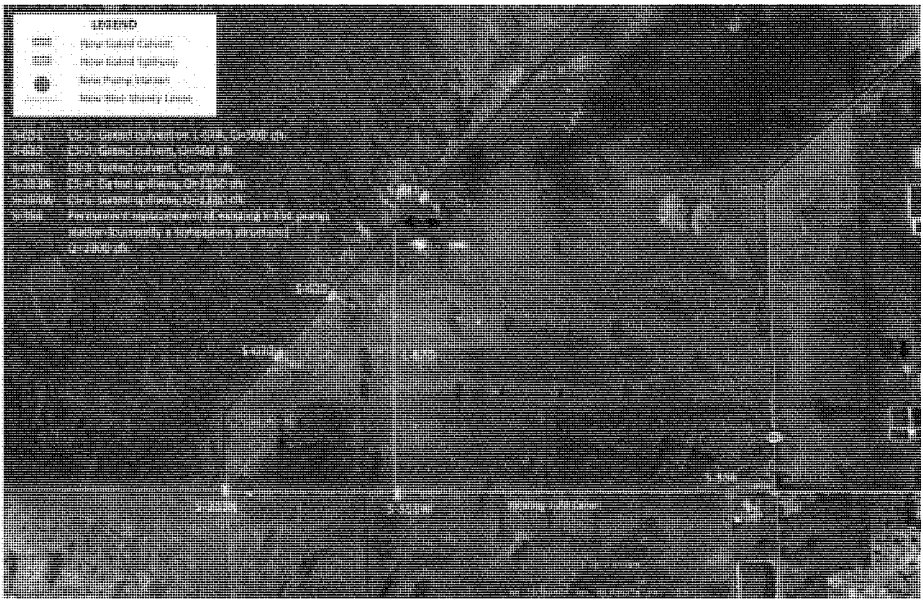
Cut Fill Study

	Excavation									
	organic		common		Blasted Cap Rock		Inter-Bedded Material		Levee Excavation	
Structure	BCY	LCY	BCY	LCY	BCY	LCY	BCY	LCY	BCY	LCY
S-620	-	-	-	-	700.0	1,050.00	21,653.3	32,480.00	-	-
S-621	-	-	-	-	-	-	8,711.1	13,066.7	-	-
S-622	-	-	-	-	-	-	-	-	69,100.0	86,375.0
S-8A	10,813.3	13,516.7	-	-	63,911.1	95,866.7	39,020.1	58,530.2	-	-
S-630	133.3	166.7	-	-	933.3	1,400.0	-	-	-	-
L-4	-	-	-	-	-	-	-	-	85,066.7	106,333.3
Miami Canal	-	-	-	-	-	-	-	-	-	-
Tree Islands	-	-	-	-	-	-	-	-	-	-
L-5E	65,013.9	81,267.4	-	-	433,425.9	650,138.9	134,362.0	201,543.1	-	-
L-5W	77,500.0	96,875.0	-	-	516,666.7	775,000.0	232,500.0	348,750.0	-	-
TOTAL	153,460.6	191,825.7	-	-	1,015,637.0	1,523,455.6	436,246.6	654,369.9	154,166.7	192,708.3

Processed LCY	=	2,370,533.8	LCY	5.96%
Needed LCY	=	2,229,348.9	LCY	
rejected/unused processed	=	141,184.9	LCY	

	Fill	
	Levee Quality Material	
Structure	ECY	LCY
S-620	21,653.3	24,468.3
S-621	5,155.6	5,825.8
S-622	5,155.6	5,825.8
S-8A	46,997.9	53,107.7
S-630	3,022.2	3,415.1
L-4	-	-
Miami Canal	1,608,821.3	2,011,026.7
Tree Islands	111,220.9	125,679.6
L-5E	-	-
L-5W	-	-
TOTAL	1,802,026.9	2,229,348.9

Blue-Green-Yellow Line – Distribution, Conveyance and Seepage Management



Feature of Work:	INCREASE S-333 (N) TO 2500 CFS BY ADDING A 1150 CFS GATED STRUCTURE AND DISCHARGE CANAL

Scope Given:	Works in conjunction with S-333 to increase flow capacity (total of 2500 cfs) from WCA-3A to Northeast Shark Rive Slough

Reference for Scope Basis:	Engineering Appendix, March 2013, Section A.7.3.5, p. 113

Scope Assumptions:	- Assume similar to structure S-65EX. - Assume given dimensions in the engineering appendix govern over provided design documents for similar structu if no dimensions are given in the engineering appendix all dimensions will come from the similar structure. - Assume material as 1.5 ft of organic, 10 ft of cap rock material and the remainder is inter-bedded material. - Assume aprons are in addition to the concrete structure shown in the provided drawings. - Assume power for the structure will be provided from local power lines located .5 miles from the structure. - Assume that a diesel generator is needed for backup power. - Assume 50 ft deep sheet pile and will be driven for wingwalls and components of the structure similar to S-65EX - Assume rim ditch dewatering will be ongoing for the gated structure. - Assume 50 KW Diesel Generator with 1000 gallon above ground tank. - Assume new canal construction will require degrading of levees for these features and the levee dimensions are 14ft high with 3:1 side slopes and a 14ft wide top.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

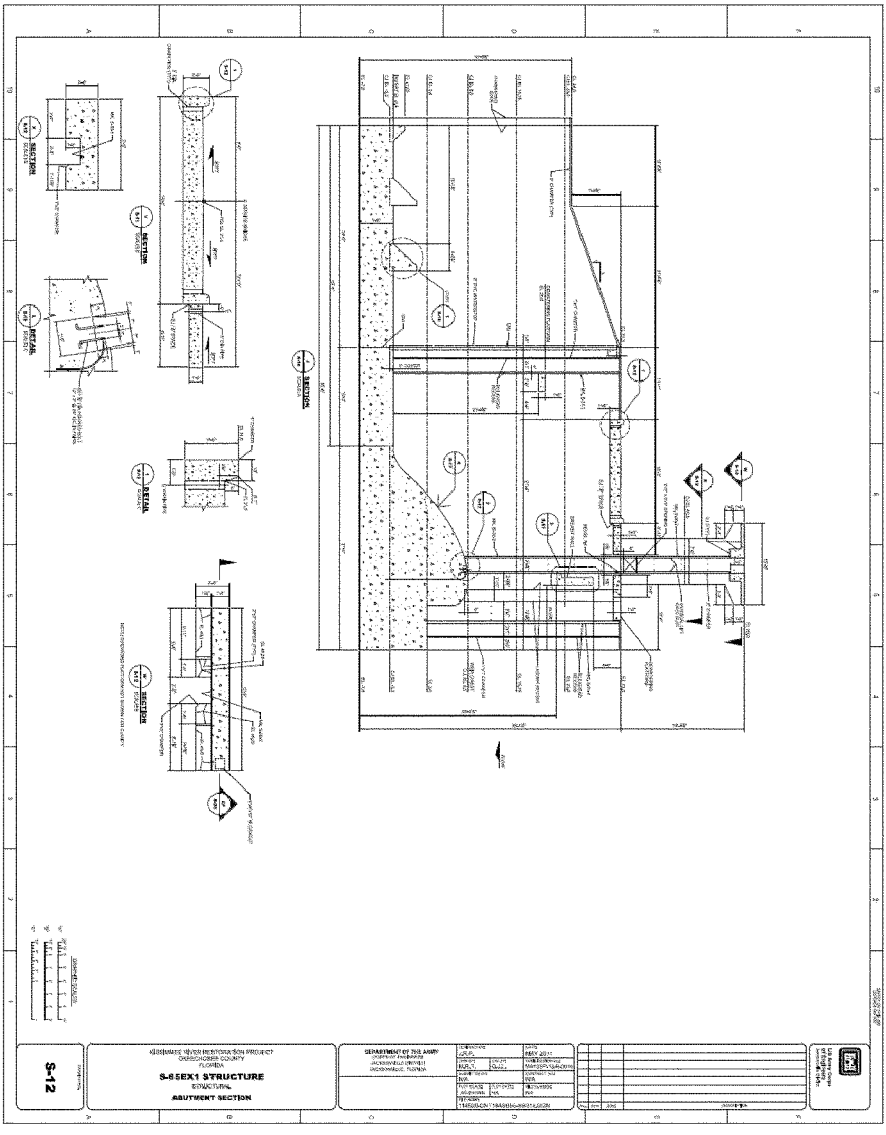
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	-Sheet pile will be required for structural features and rim ditch dewatering will be utilized to dewater the site. -Existing Canal dimensions: Bottom width 35 ft, top width 135 ft, invert- (-)10 NGVD, Top of Bank 15 ft (Total depth 25 ft). Excavation of materials to allow for construction of the foundation of the cross canal gate structure and the canal apron/wing wall. Concrete work for structure followed by apron and wing walls. Backfill suitable material around the structure and import riprap. Construct control station, diesel generator, and fuel storage. Place gates and other associated closure devices for the gate structure. Excavate new canal from overflow structure to L-29 canal. Establish flow to new canal through structure.

Key Challenges, Risks, and Opportunities	

Representative Drawings/Photos: S-333N Gated Spillway w/ New Canal



Feature of Work:	INCREASE S-333 (N) TO 2500 CFS BY ADDING A 1150 CFS GATED STRUCTURE AND DISCHARGE CANAL

Quantity Take Off:

Canal Excavation For New Canal

Length	=	1,300.0	FT							
Total Depth	=	25.0	FT							
Thickness of Organic	=	1.5	FT							
Thickness of Cap Rock Material	=	10.0	FT							
Thickness of Inter-Bedded Material		13.5	FT							
Slope1	=	2.0	:1							
Slope2	=	2.0	:1							
Bottom Width	=	35.0	FT							
Top Width	=	135.0	FT							
Cross Section	=	2,125.0	SF							
Cross Section Organic	=	198.0	SF							
Cross Section of Cap Rock	=	1,090.0	SF							
Cross Section of Inter-Bedded Material	=	837.0	SF							
Surface Area of Canal	=	175,500.0	SF	=	4.0	ACRE				
Organic Volume	=	257,400.0	CF	=	**9,533.3**	BCY	=	11,916.7	LCY	
Cap Rock Volume	=	1,417,000.0	CF	=	**52,481.5**	BCY	=	78,722.2	LCY	
Inter-Bedded Material Volume	=	1,088,100.0	CF	=	**40,300.0**	BCY	=	60,450.0	LCY	

Haul road length	=	**1**,300.0	FT
Haul road width	=	**14**.0	FT
Haul Road Area	=	2,022.2	FT

Silt Fence

Silt fence	=	2,600.0	FT	
Floating silt boom	=	810.0	FT	assumed 6 times the width of the canal

Remove Levee

Length	=	168.8	FT							
Height	=	10.0	FT							
Slope1	=	3.0	:1							
Slope2	=	3.0	:1							
Top width	=	10.0	FT							
Bottom Width	=	70.0	FT							
Unsuitable Material	=	0.5	FT							
Cross Section	=	400.0	SF							
Surface Area of Levee	=	12,360.2	SF	=	0.3	ACRE				
volume of unsuitable	=	6,180.1	CF	=	228.9	BCY	=	286	LCY	
usable volume	=	61,319.9	CF	=	**2,271.1**	BCY	=	2,839	LCY	
Total Volume	=	67,500.0	CF	=	2,500.0	BCY				

Structure Dimensions and volumes

Number of Gates	=	1.0	EA				
Superstructure/Gate Structure							
tower cross section	=	144.9	SF				
number of towers	=	2.0	EA				
pier cross section	=	154.1	SF				
number of Piers	=	-	EA				
tower width	=	3.5	FT				
Pier Height	=	35.0	FT				
beam cross section	=	15.0	SF				
Beam Length	=	25.0	FT				
volume	=	1,389.3	CF	=	51.5	CY	
volume of elevated beam	=	375.0	CF	=	13.9	CY	
Width	=	69.0	FT				
Cross section of platform,bridge,brestwall	=	46.5	SF				
Volume	=	3,211.3	CF	=	118.9	CY	
OGEE volume							
Cross section	=	143.9	SF				
width	=	29.0	FT				
OGEE Spillway volume	=	4,173.1	CF	=	154.6	CY	
Spillway wall volume (Abutment)	=	1,153.3	CY	Structure is 90' long and cross section of wall is 173 SF			
Approach apron	=	187.8	CY	Assumed 39ft long 29 ft wide and 5 ft thick per S-65EX design			
Stilling Basin	=	187.8	CY	Assumed 39ft long 29 ft wide and 5 ft thick per S-65EX design			

Wing Walls Assumed approach wing walls similar to downstream wing wall plan from S-65EX-1 with anchor walls. Construction will consist of driven sheet pile with a 2'x2' concrete pile cap. The anchor walls will be 1 ft thick reinforced concrete. Concrete anchor wall dimensions will match wing wall dimensions. The wing wall and concrete anchor wall will be connected by #10 all thread grade 70. A C8x18.75 channel will be attached to the back of the wing wall where the anchors will be attached to.

wing walls								
Number	=	4.0	Each					
Length average US and DS	=	95.5	FT					
US Depth	=	44.5	FT					
DS Depth	=	26.5	FT					
area of sheet pile	=	13,561.0	SF					
Pile Cap								
height	=	2.0	FT					
width	=	2.0	FT					
volume	=	56.6	CY					
Rod length	=	60.0	FT					
spacing	=	4.0	FT					
number of rods	=	96.0	EA	total length	=	5,760.0	FT	
Anchor Walls								
height	=	8.0	FT					
thickness	=	1.0	FT					
length	=	382.0	FT					
volume	=	113.2	CY					
Rip Rap				Lengths and depths assumed to extend beyond aprons.				
Length	=	440.0	FT					
width	=	39.0	FT					
Depth	=	3.0	FT	average of all depths				
volume	=	1,906.7	ECY	=	3,050.7	TON		

Rim Ditch Excavation

Length	=	160.0		ft	Length of excavation			
Width	=	55.0		ft	Bottom width of excavation			
Canal Dimension	=	3ft deep x 3 ft wide						
Ditch volume	=	3,870.0	CF	=	**143.3** BCY	=	179.2	LCY
Excavation for Footing Organic Volume	=	13,200.0	CF	Assume 55 ft wide by 160 ft long (per S-65EX) and 10' deep to allow for				
Excavation for Cap Rock Volume		74,800.0	CF	construction of the underwater seal and structural footings. Assume 1.5				
Organic Volume	=	**488.9**	BCY	ft Organic and 10 ft of Cap Rock remainder is inter-bedded material				
Cap Rock Volume	=	**2,770.4**	BCY					
Excavation east and west canal banks for	=	177,600.0	CF	Assume top of bank is 15 ft NGVD (Per table A-14) and bottom of excavation and				
installation of wing walls.	=	**6,577.8**	BCY	bottom of excavation is at -23.5 ft NGVD (Total depth 37'). Assume excavation is 160 ft				
	=	9,866.7	LCY	long and extends the bottom of the canal an additional 15' per bank. Assume material Levee Grade Material				
Sheet pile/cofferdam	=	1,200.0	LF	Assume 1200 LF of sheet pile/cofferdam to go around entire work site. Sheet pile will				
Area	=	72,000.0	SF	be driven 60ft deep. All sheet pile used as a coffer dam will be removed.				

Gate weight calculations

3/8" Plate steel	=	15.3	lb/sq ft				
1/2" Plate steel	=	20.4	lb/sq ft				
1" Plate Steel	=	40.8	lb/sq ft				
Gate Skin 3/8" Plate Steel	=	392.0	sq ft				Assume Gate dimensions of 14'x28'
3/8" Plate stiffeners and seal angles	=	87.0	sq ft				Assume 5 sq ft for seal angles and 82 for stiffeners
Horizontal C-Channels (1/2")	=	607.0	sq ft				Assume each channel is equivalent to 26"x28' (10 Channels).
Vertical C-Channels (1/2")	=	303.0	sq ft				Assume each vertical channel is 26"x14' (10 Channels).
Pull Pad eyes (1")	=	4.0	sq ft				Assume 4 pad eyes per gate @ 1 sq ft each
Total 3/8" Plus 10% for misc. items	=	526.9	sq ft	=	8,061.6	lbs	
Total 1/2" plus 15% for misc items	=	1,046.5	sq ft	=	21,348.6	lbs	
Total 1" steel	=	4.0	sq ft	=	163.2	lbs	
lbs/sq ft for 29'x14.6' gate	=	69.8	lb/sq ft				
Area of single S-333N Gate	=	612.5	sq ft				assumed 3 ft bigger then opening in each direction
Approximate weight of S-333N Gate	=	42,781.5	lb				
Overweight factor for larger gates (10%)	=	47,059.7	LB EA				

Control Building / Generator Shelter

Shelter square footage	=	315.0	sq ft	Assume Shelter will be 10' tall and have a 8" concrete block partition wall full height. Assume one 4'-4" steel door and one 3'-4" door. Assume 4 3' x 5' Louvers along with a generator radiator louver and exhaust port.
Excavation/backfill for shelter	=	163.3	ECY	Building will be set on grade with 12" capillary water barrier and geotextile fabric and a 12" thick concrete curb around the building perimeter.
Generator Fuel Tank	=	1000 Gallon		
Fuel Pad dimensions	=	96.0	SF	Assume 8'x12'x12" thick reinforced concrete slab on grade pad.

Gate embeds/seal lengths

Gate Dimensions				
Width	=	29.0	FT	
Height	=	14.0	FT	
Gate well Height	=	42.0	FT	
Gate Well Embed	=	113.0	FT	
Total Embed length	=	113.0	FT	1 Gate
Seal Length	=	86.0	FT	seal length is the perimeter of bottom and both sides.
Total Seal length	=	86.0	FT	Total of single gate
Up and Downstream Bulkhead Slot	=	196.0	FT	6 times vertical plus width of new gate per slot
Bulkheads	=	47,059.7	LB EA	assume same size as gates
number	=	2.0	EA	two per gate needed
Total Length of imbeds	=	309.0	FT	
Total Weight of gates and stop logs	=	141,179.0	LB	= 70.6 TON
TOTAL J BULB for GATES AND STOP LOGS	=	258.0	FT	

Backfill

Structure Backfill	=	6,577.8	ECY	=	7,432.9	LCY

Railings and ladders

Railing				
Length	=	694.0	FT	assumed 4 time the length of a wing wall and 6 times the width of the
Height	=	3.5	FT	structure and twice the length
Ladders				
Count	=	6.0	EA	assumed ladders on each side of the structure.
Height	=	17.5	FT	average of all three types
total height	=	105.0	FT	

Boat Barrier

Number	=	2.0	EA
Length each	=	135.0	FT
Total Length	=	270.0	FT

Site Fencing

Length	=	1,000.0	FT	assumed a total of 1000 LF of chain link fencing.
Gates	=	4.0	EA	assumed

Access road

Length	=	600.0	FT		assumed	
Width	=	14.0	FT		assumed	
Area	=	8,400.0	SF	=	933.3	SY

SWPPP

Length	=	3,800.0	LF	
Floating Silt Boom	=	1,350.0	LF	assumed 10 times the top width of the canal

Haul road

Length	=	3,000.0	LF
width	=	14.0	FT
Area	=	4,666.7	SY

Site Restoration

Area	=	6,666.7	SY

Feature of Work:	New S-356 Pump Station 1000 CFS in vicinity of existing S-356.

Scope Given:	Seepage Control and Water Supply. S-356 Pump station will replace the existing temporary S-356 pump to provide permanent seepage return to Northeast Shark River Slough

Reference for Scope Basis:	Engineering Appendix, March 2013, Section A.7.3.5, p. 115

Scope Assumptions:	Scope Assumptions: - Assume similar to structure Pump Station 357. - Assume given dimensions in the engineering appendix govern over provided design documents for similar structu if no dimensions are given in the engineering appendix all dimensions will come from the similar structure. - Assume there will be a total of 4 pumps, three 350 cfs diesel pumps and one 150 cfs electric pumps. - Assume existing temporary pump station will remain operational during construction of new pump station. - Assume existing Gated Structure S-334 will remain in operation during and after construction. - Assume new pump station will be installed north of the current S-334/S-356 location and require excavation of a basin at the suction side of the new pump station. - Assume discharge of pumps will be piped by five 60" diameter steel pipe and will terminate in a discharge structu built into Canal for the 60" discharge pipes. - Assume demolition of the existing temporary pump station will occur after the new pump station is fully operational. - Assume existing pump station contains four 48" pipes that will have to be removed including discharge headwall. Backfill and re-grade to existing levee height. - Assume existing levee is 10.4ft tall and 170 ft long with 2:1 side slopes and a 10 ft crest. - Assume existing piping is buried with 3 ft of cover (total excavation depth 7' to remove piping). - Assume the discharge structure will consist of a concrete headwall full height of the canal 30 ft wide 18 inch thick reinforced concrete, 20'x30' apron 18 inch thick reinforced concrete, wing walls extending 30ft up and downstrean of the discharge point sloping from full height of the canal to bottom of canal 18 inch thick reinforced concrete anc riprap lining 136 ft beyond the concrete apron. - Assume the excavation will extend 3 feet below the seepage canal bottom elevation. The pump station will requir removal of 7 ft of organic material, and per designer the remaining material is rippable limestone rock. - Assume pump station will be constructed of reinforced concrete below grade and a Combination of cast-in-place columns and reinforced CMU walls. - Assume a fuel pad will be required for storage tanks for the diesel pump and the diesel generator, assumed size o 20' by 20' 2 feet thick reinforced concrete.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

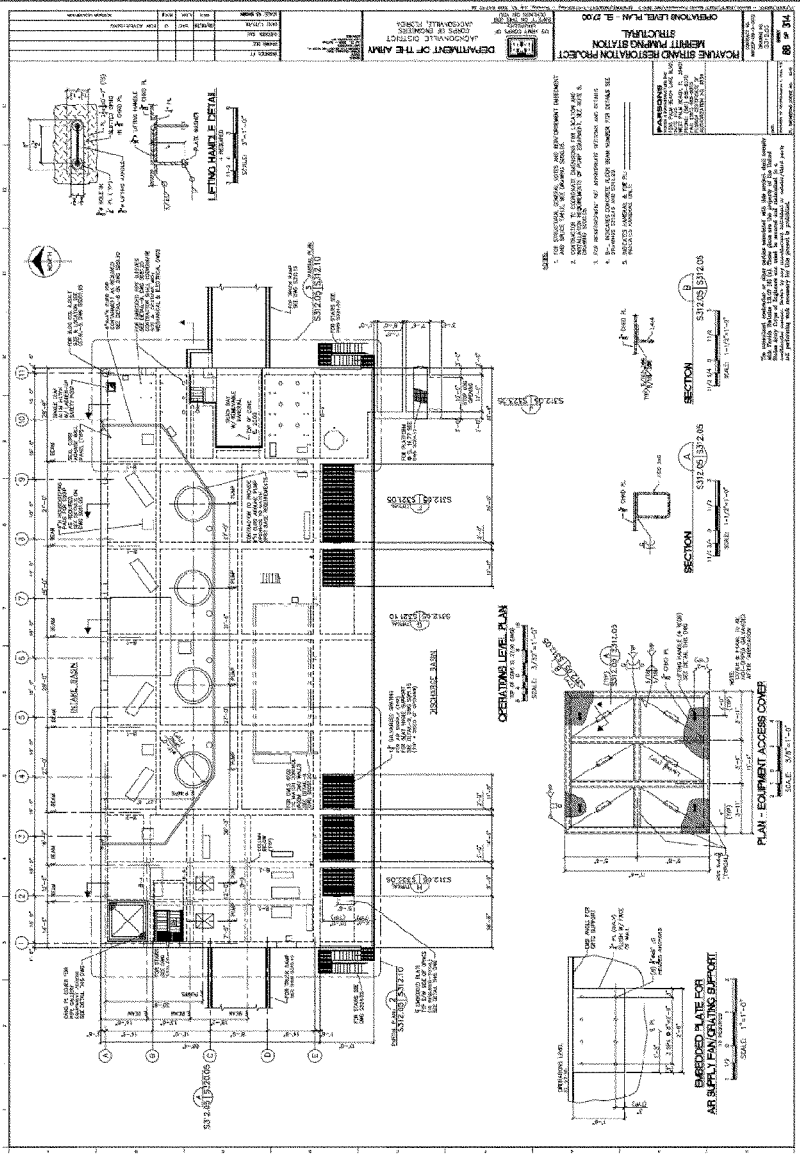
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	Sequence of Work: Sheet pile will be utilized for wingwalls as shown on the similar structure and utilize rim ditch dewatering for the excavation. Cap slab will be placed in bottom of excavation. Structure will be built and excavation for the inlet basin will commence. Suction apron will be placed along with excavation for discharge piping and discharge headwall/discharge apron. New pump station will be operational and the existing temporary pump station will be removed. Excavate out discharge piping and backfill levee.

Key Challenges, Risks, and Opportunities	

Representative Drawings/Photos: New S-356 Pump Station



Feature of Work:	New S-356 Pump Station 1000 CFS in vicinity of existing S-356.

Quantity Take Off:

FEB Seepage Pump Station Excavation.

Length	=	105.0	FT						
Total Depth	=	21.5	FT						
Thickness of Organic	=	7.0	FT						
Thickness of Rippable Rock	=	14.5	FT						
Slope1	=	1.0	:1						
Slope2	=	1.0	:1						
Bottom Width	=	15.0	FT						
Top Width	=	58.0	FT						
Cross Section	=	784.8	SF						
Cross Section Organic	=	357.0	SF						
Cross Section of Cap Rock	=	427.8	SF						
Organic Volume	=	37,485.0	CF	=	1,388.3	BCY	=	1,735.4	LCY
Cap Rock Volume	=	44,913.8	CF	=	1,663.5	BCY	=	2,495.2	LCY
Backfill	=	8,239.9	CF	=	305.2	BCY	=	423.1	LCY
Assume Backfill is 10% of excavated quantity.									
Assume Clear and Grub similar to work area for the Merritt Pumping Station	=	18.0	ACRE	=	87,120.0	SY			

Inflow and outflow Canal Excavation

Length	=	700.0	FT						
Total Depth	=	17.0	FT						
Thickness of Organic	=	7.0	FT						
Thickness of Common	=	-	FT						
Thickness of Cap Rock	=	10.0	FT						
Slope1	=	2.0	:1						
Slope2	=	2.0	:1						
Bottom Width	=	40.0	FT						
Top Width	=	108.0	FT						
Surface Area of Canal	=	75,600.0	SF	=	1.7	ACRE	=	8,400.0	SY
Organic Volume	=	460,600.0	CF	=	17,059.3	BCY	=	21,324.1	LCY
Cap Rock Volume	=	420,000.0	CF	=	15,555.6	BCY	=	23,333.3	LCY

Levee Degrade

Length	=	730.0	FT	Assume Degrade of levee required due to location of new pump station.					
Height	=	10.4	FT						
Slope1	=	2.0	:1						
Slope2	=	2.0	:1						
Top width	=	10.0	FT						
Bottom Width	=	51.6	FT						
Cross Section	=	320.3	SF						
Surface Area of Levee	=	39,946.6	SF	=	0.9	ACRE			
Volume	=	233,833.6	CF	=	8,660.5	BCY	=	9,786.4	LCY
base area of levee	=	37,668.0	SF	=	4,185.3	SY	=	0.9	Acre
side slopes of levee	=	32,646.6	SF	=	3,627.4	SY	=	0.7	Acre
roadway area	=	7,300.0	SF	=	811.1	SY	=	0.2	Acre

Levee Construction

Length	=	880.0	FT							
Height	=	10.4	FT							
Slope1	=	2.0	:1							
Slope2	=	2.0	:1							
Top width	=	10.0	FT							
Bottom Width	=	51.6	FT							
Cross Section	=	320.3	SF							
Surface Area of Levee	=	48,154.8	SF	=	1.1	ACRE	=	5,350.5		
Volume	=	281,881.6	CF	=	10,440.1	ECY	=	11,797.3	LCY	
base area of levee	=	45,408.0	SF	=	5,045.3	SY	=	1.0	Acre	
side slopes of levee	=	39,354.8	SF	=	4,372.8	SY	=	0.9	Acre	
roadway area	=	8,800.0	SF	=	977.8	SY	=	0.2	Acre	

Levee Sub Surface Excavation

Thickness of Organic	=	7.0	FT							
Total depth	=	7.0	FT							
bottom width	=	79.6	FT							
Slope of Excavation	=	2.0	:1							
Top Width of Excavation	=	107.6	FT							
Excavation of Organic	=	655.2	SF							
Volume of Organic	=	576,576.0	CF	=	21,354.7	BCY	=	26,693.3	LCY	
Total Excavation	=	576,576.0	CF							
Total Backfill of Excavation	=	576,576.0	CF	=	21,354.7	ECY	=	24,130.8	LCY	
Road length	=	880.0	FT							
Road width	=	14.0	FT							
minimum thickness	=	0.5	FT							

Removal of existing S-356 Temporary Pump Station and backfill of Temporary Pump Station Intake

Excavation volume for removal of Piping	=	67,240.0	CF	Assume excavation area is 6,724 SF and excavation is 10 ft deep.						
	=	2,490.4	BCY	=	3,113.0	LCY				
Intake Backfill										
Length	=	142.5	FT	Assume averaged length is 142.5 ft						
Height	=	10.0	FT	Assume average depth is 10 ft						
Slope1	=	2.0	:1	assume side slope of 2:1						
Slope2	=	2.0	:1							
Bottom Width	=	30.0	FT	Assume Bottom width of 30 ft with top width at 70 ft.						
Top Width	=	70.0	FT							
Cross Section	=	500.0	SF							
Backfill Volume	=	71,250.0	CF	=	2,638.9	ECY	=	2,981.9	LCY	
new surface area of backfill	=	9,975.0	SF	=	1,108.3	SY	=	0.2	Acre	
Total Backfill removed temporary pump station	=	5642.2	ECY	=	6375.7	LCY				

Care and Diversion of Water

Construction Sequence:

1 Construct perimeter concrete ring beam and rock anchors.
2 Place Sheet piling and connect piling to concrete ring beam. Excavate. Assume sheet pile length of 36 ft
3 Install rock anchors for concrete seal slab. Anchor length 17'-6" slab rock anchor.
4
Place Concrete Seal slab. 6'-0" thick and dimensions of sheet pile
5 Dewater cofferdam and prepare top of concrete base mat slab
6 Place concrete walls to elevation 9'-0" at pump structure monolith prior to abandoning or removing in place cofferdam sheet piles. Remove ring beams in inlet and outlet.
7 install lateral bracing for walls.
8 Construct service bridge slab. Remainder of walls and operating floor slab.
9 Install sheet pile wing walls.

# of pump station Bays	=	4.0		
Cofferdam width per pump station bay	=	15.0	ft	Assume Per S-101
Total width length	=	60.0	ft	
Length (Up and downstream) of Cofferdam	=	90.0	ft	Assume per S-101
Area of Cofferdam sheet pile to remain in place	=	10,800.0	SF	
Area of cofferdam to be removed	=	7,200.0	SF	
Total perimeter length (length of sheet pile/ring beam)	=	300.0	ft	
Length of Sheet pile to Be utilized as wing wall	=	186.0	ft	
Volume of ring beam (Reinforced Concrete	=	70.4	CY	Per detail S-103
# of 54' ring beam anchors @ 10' OC	=	30	ea	Per detail S-101
# of 17'-6" uplift slab rock anchors	=	54	ea	
Volume of Concrete seal/uplift slab	=	1,200.0	CY	Assume 6' thick
Width of each Bay	=	15.00	ft	Assumed per similar PS-357
Length of Operating Floor	=	45.0	ft	
Width of Operating Floor	=	60.0	ft	
Horizontal concrete volume	=	800.0	CY	
Vertical Concrete	=	1,500.0	CY	
Service Bridge Elevated Flatwork	=	190.1	CY	Total Elevated Flatwork = 446.4 CY
Operating Floor (Elevated Flatwork	=	225.0	CY	
Elevated Vertical Work (Operating floor to service bridge)	=	31.3	CY	
Roof slab / Metal Deck	=	220.0	CY	
Loading Truck Ramp (horizontal Concrete)	=	4,903.0	SF	= 272.4 CY Assumed From Merritt Pump Station
SF of Generator, Electric and Office/Control	=	900.0	SF	Assume Generator room. Electric Room and Office control room is 20ftx45ft
Volume of Concrete for Gen, Elec and Office	=	1,500.0	CF	= 55.6 CY Assume 1.67 ft thick
Assume 10 18"x18"x26' tall Columns	=	43.3	CY	
Tilt Up 7-1/2" Thick Precast Panels	=	5,250.0	SF	Assume Similar to Merritt Pump Station
CMU Wall Dimensions (Exterior Surface Area of CMU)	=	8,500.0	SF	
Roof 32" Double tee units 56 ft long required	=	8	each	

Intake Basin Concrete	=	89	CY	
Discharge Basin Concrete Apron	=	133.3	CY	Assume 36" thick concrete
Stone Protection Riprap discharge	=	1,688.9	CY	Assume 5 ft thick layer of riprap lining the C-625W canal upstream 60 ft and downstream 60 ft.
Stone Protection Inlet	=	750.0	CY	Assume 36" thick layer of riprap lining the sides and bottom for 150' upstream
Trash Rack Surface Area (total)	=	1,680.0	SF	Assume Trash rake is 28 ft tall and covers the width of the operating floor each individual covers the width of the bays (14ft).
Roll Up Garage Door	=	168.0	SF	Assume Roll up garage door 12'x14'
# of Doors	=	4.0	ea	Assume 1 set of double doors and two other doors
# louver openings	=	8.0	ea	Assume 8 louver openings 7'-4" square
Overhead Crane	=	2.0	ea	Assume 2 overhead cranes @ 25 tons each
Power Line Connection	=	2,500.0	LF	Assume power available 2500 lf from site
Septic tank system	=	1.0	ea	Assume 1 septic tank system
Potable water	=	1.0	ea	Assume 1 potable water well will be required
Generator Fuel Tank	=	2000 Gallon	ea	Assume five 2000 gallon fuel tanks required
Fuel Pad dimensions	=	2,000.0	SF	Assume two 100'x20'x8" thick reinforced concrete slab on grade pad.
		49.4	CY	

Discharge Piping

48" discharge pipe	=	15.0	LF/ea	Assume Pumps will have a 48" Discharge Piping
Concrete Encasement	=	146.6	CY	Assume 2 ft of concrete to encase piping
Floor Grating	=	240.0	SF	Assume 14' x4 ft wide for each pump bay.
Ladders	=	120.0	VLF	Assume 30 ft per pump bay
Railings	=	180.0	LF	Assume a handrail on the up and downstream side and one a width of the operating floor

Haul road length	=	21,120.0	FT				
Haul road width	=	14.0					
Haul road thickness	=	1.0	FT				
				SF	=	32,853.3	see
Area	=	295,680.0					

Chain link Fence	=	2,280.0	LF	Assume Similar to Merritt Pump Station
Silt Fence	=	3,700.0	LF	Assume similar to Merritt Pump Station
Silt Boom	=	600.0	LF	Assume similar to Merritt Pump Station

Assume Haul road will require no maintenance only traffic control at the exit of the site onto HW 41 and the entrance to the processor located near S-333

Feature of Work:	S-631 Gated Culvert 500 CFS GATED CULVERT IN L-67A LEVEE

Scope Given:	S-631 conveys flows from the WCA-3A to through the Blue Shanty Flow way to provide flows to the Shark River Slough

Reference for Scope Basis:	Engineering Appendix, March 2013, Section A.7.3.5, p. 112

Scope Assumptions:	- Assume similar to structures S-276 and S-277 contrary to the design guidance provided in the Engineering Appenc paragraph A.7.4.4 which states "S-631, S-632, and S-633 are gated culverts that will be designed similar to the culverts on Decomp." Culvert is listed in Table A-29 as a single 11 ft x 11 ft concrete box culvert not multiple HDPE pipes. - Assume Levee and excavation quantities will be based on the profiles provided by the Decomp drawings and will correlate to the elevations given in the Engineering Appendix. - Assume an earthen cofferdam and rim ditch dewatering will be utilized to dewater the site. - Assume box culvert will be cast-in-place concrete. -Assume Excavation will be to the same depth below finished grade as shown in contract drawings for similar projects. Assume material as 1.5 ft of organic, 10 ft of Cap Rock and the remainder is inter-bedded material. - Assume a distribution canal will extend 500 ft beyond the discharge of the culvert and will taper from -4.5 ft NGV (Invert elevation) up to 9 ft NGVD (Natural Grade). Initial 150 ft will be lined with 3' of riprap and the new channel will have 1:2 side slopes. - Assume inlet channel will be excavated and will taper from -4.5 ft NGVD (Invert elevation) to 1.4 ft NGVD (Canal Bottom elevation). Assume inlet channel will have 1:2 side slopes and extend from the headwall to the existing channel (140 ft) and will be lined with 3'thick riprap that will extend 20 ft up and downstream L-67A Canal. - Assume power will be provided from power lines in the area approximately 3 miles. - Assume that a diesel generator is needed for backup power.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

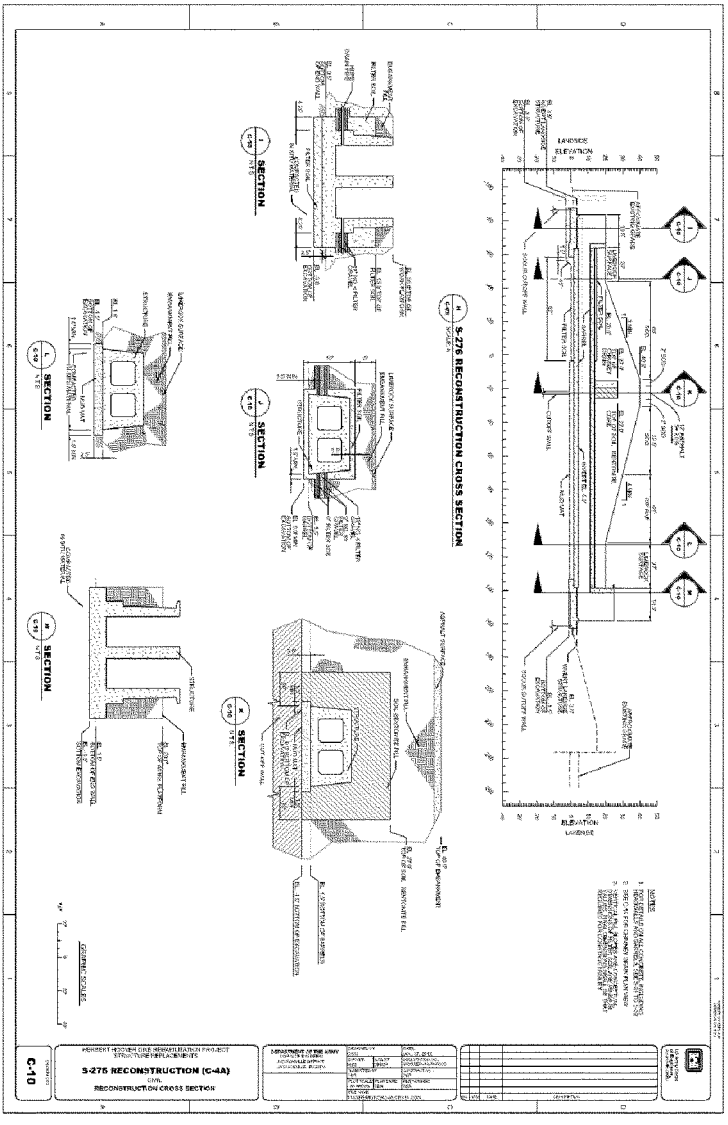
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	Organic (muck) will be excavated and hauled off-site to a disposal facility. Cofferdam material will be imported to construct the cofferdam. Degrade levee and establish the earthen cofferdam around the inflow and outflow canal Excavated outflow canal and levee down to -7 ft NGVD to allow for installation of new box culvert, headwall and outlet/Gated structures with wing walls. Backfill levee to original cross section and line discharge canal with rip ra Remove cofferdam and excavate inlet channel and line with riprap to the existing L-67A Canal. Install emergency backup generator shelter and fuel tank pads and restore site.

Key Outstanding Questions/Issues:	Lacks details on motors needed to operate gate. Lacks details on source of power for said motors.

Representative Drawings/Photos: S-631



Feature of Work:	S-631 Gated Culvert 500 CFS GATED CULVERT IN L-67A LEVEE

Quantity Take Off:

Culvert Excavation

Thickness of Organic	=	1.5	FT						
Thickness of Cap Rock	=	3.0	FT						
Total depth	=	4.5	FT						
bottom width	=	58.0	FT						
Length	=	600.0	FT						
Slope of Excavation	=	2.0	:1						
Top Width of Excavation	=	76.0	FT						
Excavation of Organic	=	109.5	SF						
Excavation of Cap Rock	=	192.0	SF						
Volume of Organic	=	65,700.0	CF	=	**2,433.3**	BCY	=	3,041.7	LCY
Volume of Cap Rock	=	115,200.0	CF	=	**4,266.7**	BCY	=	5,333.3	LCY
Total Excavation	=	180,900.0	CF						
Total Backfill of Excavation	=	180,900.0	CF	=	6,700.0	ECY	=	7,571.0	LCY

Canal Excavation

Includes excavation under levee but excludes the levee degrade (captured in next section below)

Length	=	650.0	FT	Length from L-67 canal to end of discharge canal					
Total Depth	=	6.8	FT	Assume average depth of canal					
Thickness of Organic	=	1.5	FT						
Thickness of Cap Rock	=	5.3	FT						
Slope1	=	2.0	:1						
Slope2	=	2.0	:1						
Bottom Width	=	40.0	FT						
Top Width	=	67.0	FT						
Cross Section	=	361.1	SF						
Cross Section Organic	=	96.0	SF						
Cross Section of Cap Rock	=	267.1	SF						
Surface Area of Canal	=	43,550.0	SF	=	1.0	ACRE			
Pete Organic	=	62,400.0	CF	=	**2,311.1**	BCY	=	2,888.9	LCY
Cap Rock Volume	=	173,628.0	CF	=	**6,430.7**	BCY	=	9,646.0	LCY
Haul road length	=	650.0	FT						
Haul road width	=	14.0	FT						
Haul road thickness	=	1.0	FT						

Levee Degrade (Degrade down to surface elevation canal/box culvert excavation captured above)

Length	=	175.0	FT							
Height	=	7.0	FT							
Slope1	=	2.0	:1							
Slope2	=	2.0	:1							
Top width	=	14.0	FT							
Bottom Width	=	42.0	FT							
Cross Section	=	196.0	SF							
Surface Area of Levee	=	13,406.7	SF	=	0.3	ACRE				
Volume	=	34,300.0	CF	=	**1,270.4**	BCY	=	1,588.0	LCY	
base area of levee	=	7,350.0	SF	=	816.7	SY	=	0.2	Acre	
side slopes of levee	=	10,956.7	SF	=	1,217.4	SY	=	0.3	Acre	
roadway area	=	2,450.0	SF	=	272.2	SY	=	0.1	Acre	

Inlet and Outlet Works

Number	=	4.0	EA	assumed intake/outlet are the same assumed 2 per each end gate and bulkhead
Foundation				
Length	=	8.0	FT	
Depth	=	5.0	FT	
Width	=	30.5	FT	
Volume	=	4,880.0	CF	= 180.7 CY
Head Walls				
Height	=	20.5	FT	
Thickness	=	3.0	FT	
width	=	19.0	FT	
openings	=	121.0	SF	
volume	=	3,222.0	CF	= 119.3 CY
End walls				
height	=	20.5	FT	
length	=	100.0	FT	total either inlet or outlet
thickness	=	2.0	FT	
volume	=	8,200.0	CF	= 303.7 CY
Railing	=	358.0	LF	
Ladders	=	2.0	EACH	
height	=	20.5	FT	

Gates IN HHD

Height	=	14.0	FT	*** STAINLESS STEEL for opening 7 by 7
Width	=	10.0	FT	
Weight	=	6,500.0	LB	
Weight Per SF	=	46.4	LB/SF	

NEW GATES

number of gates	=	4.0	EA	assumed 2 on each end 1 gate and one bulkhead.					
Height	=	18.0	FT	assumed 4 ft larger than similar gate					
Width	=	14.0	FT	assumed 4 ft larger than similar gate					
Weight % larger	=	10.0	%	assumed					
Total Weight of gates	=	12,870.0	LB EA						
Motors	=	4.0	EA						
Gear Reduction	=	4.0	EA						
Actuators	=	4.0	EA						
cable reels	=	4.0	EA						
Imbeds for gate	=	138.0	LF						
Gate Seal Length	=	256.0	LF						

Operations building

size	=	315.0	SF	8 by 8					
Electrical	=	NEEDED							
Communications	=	NEEDED							

Backfill

Area above Culvert	=	180,900.0	CF	=	**6,700.0**	ECY	=	7,571.0	LCY
Levee Construction	=	34,300.0	CF	=	**1,270.4**	ECY	=	1,435.5	LCY

Cut off walls

Number	=	1.0	EA	Assumed in FEB perimeter Levee		
Soil Bentonite Fill						
Height	=	25.0	FT			
Width	=	50.5	FT			
Thickness	=	8.0	FT			
Volume	=	10,100.0	CF/EA	=	374.1	CY/EA
Cutoff Wall						
Height	=	35.0	FT			
Width	=	50.5	FT			
Thickness	=	3.0	FT			
Volume	=	5,302.5	CF/EA	=	196.4	CY/EA
Area	=	1,767.5	SF/EA			

RIP RAP

common both sides						
number of placements	=	2.0	EA	1 each side		
Length	=	20.0	FT			
Width	=	30.5	FT			
thickness	=	4.0	FT			
Volume	=	2,440.0	CF/EA	=	90.4	CY/EA
Total Volume	=	180.7	ECY	=	289.2	TON

Boat Barrier

Number	=	2.0	EA					
Length	=	67.0	FT					
Total Length	=	134.0	FT					

SWPPP

Silt Fence	=	1,750.0	FT					

Site Fence

Length	=	1,000.0	FT	Assumed				
gates	=	4.0	FT	assumed				

Earthen Cofferdam

Length	=	350.0	FT	Assumed				
Cross Section	=	196.0	SF	ASSUMED SAME AS LEVEE DEGRADE				
Fill volume	=	68,600.0	CF	=	2,540.74	ECY	=	2,871.04 LCY
removal volume	=	68,600.0	CF	=	2,540.74	BCY	=	3,175.9 LCY

Feature of Work:	S-632 Gated Culvert 500 CFS GATED CULVERT IN L-67A LEVEE

Scope Given:	S-631 conveys flows from the WCA-3A to through the Blue Shanty Flow way to provide flows to the Shark River Slough

Reference for Scope Basis:	Engineering Appendix, March 2013, Section A.7.3.5, p. 112

Scope Assumptions:	- Assume similar to structures S-276 and S-277 contrary to the design guidance provided in the Engineering Appen paragraph A.7.4.4 which states "S-631, S-632, and S-633 are gated culverts that will be designed similar to the culverts on Decomp." Culvert is listed in Table A-29 as a single 11 ft x 11 ft concrete box culvert not multiple HDPE pipes. - Assume Levee and excavation quantities will be based on the profiles provided by the Decomp drawings and will correlate to the elevations given in the Engineering Appendix. - Assume an earthen cofferdam and rim ditch dewatering will be utilized to dewater the site. - Assume box culvert will be cast-in-place concrete. -Assume Excavation will be to the same depth below finished grade as shown in contract drawings for similar projects. Assume material as 1.5 ft of organic, 10 ft of Cap Rock and the remainder is inter-bedded material. - Assume a distribution canal will extend 500 ft beyond the discharge of the culvert and will taper from -4.5 ft NGV (Invert elevation) up to 9 ft NGVD (Natural Grade). Initial 150 ft will be lined with 3' of riprap and the new channel will have 1:2 side slopes. - Assume inlet channel will be excavated and will taper from -4.5 ft NGVD (Invert elevation) to 1.4 ft NGVD (Canal Bottom elevation). Assume inlet channel will have 1:2 side slopes and extend from the headwall to the existing channel (140 ft) and will be lined with 3'thick riprap that will extend 20 ft up and downstream L-67A Canal. - Assume power will be provided from power lines in the area approximately 3 miles. - Assume that a diesel generator is needed for backup power.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

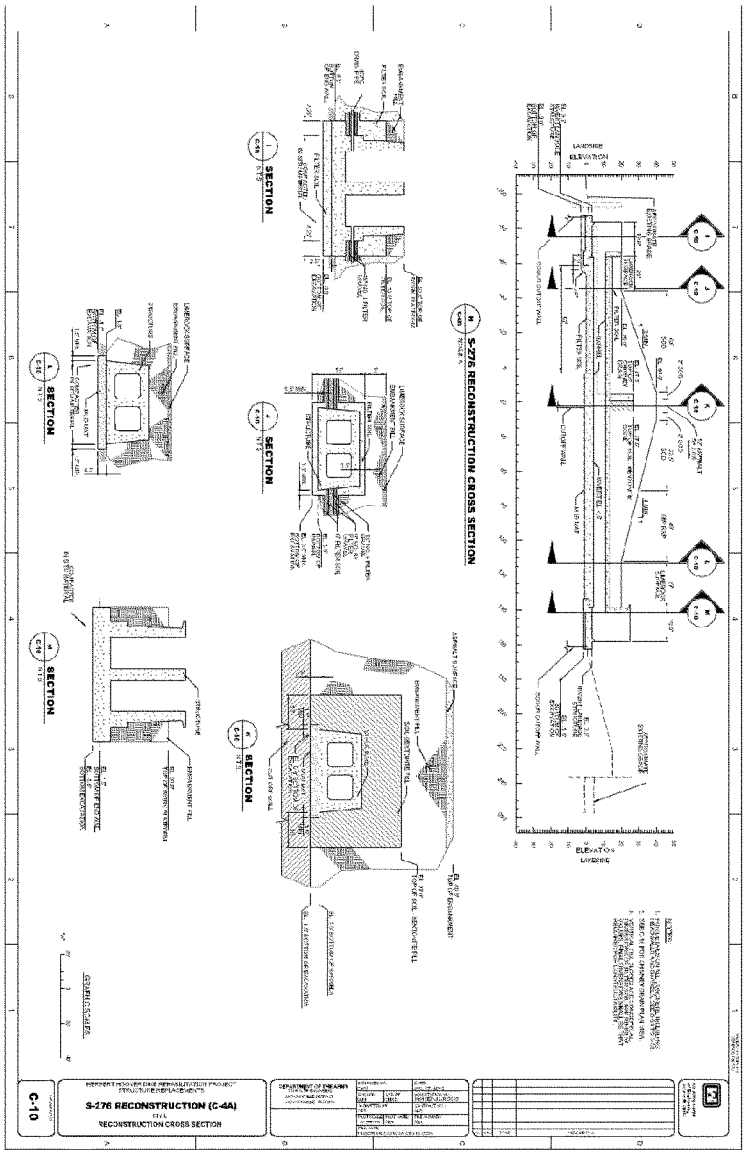
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope and assumptions were documented and sent to the design team for review. After reaching consensus on the scope and major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	Organic (muck) will be excavated and hauled off-site to a disposal facility. Cofferdam material will be imported to construct the cofferdam. Degrade levee and establish the earthen cofferdam around the inflow and outflow canal Excavated outflow canal and levee down to -7 ft NGVD to allow for installation of new box culvert, headwall and outlet/Gated structures with wing walls. Backfill levee to original cross section and line discharge canal with rip ra Remove cofferdam and excavate inlet channel and line with riprap to the existing L-67A Canal. Install emergency backup generator shelter and fuel tank pads and restore site.

Key Outstanding Questions/Issues:	Lacks details on motors needed to operate gate. Lacks details on source of power for said motors.

Representative Drawings/Photos: S-632



Feature of Work: S-632 Gated Culvert 500 CFS GATED CULVERT IN L-67A LEVEE

Quantity Take Off:

Culvert Excavation

Thickness of Organic	=	1.5	FT					
Thickness of Cap Rock	=	3.0	FT					
Total depth	=	4.5	FT					
bottom width	=	58.0	FT					
Length	=	600.0	FT					
Slope of Excavation	=	2.0	:1					
Top Width of Excavation	=	76.0	FT					
Excavation of Organic	=	109.5	SF					
Excavation of Cap Rock	=	192.0	SF					
Volume of Organic	=	65,700.0	CF	=	**2,433.3**	BCY	=	3,041.7 LCY
Volume of Cap Rock	=	115,200.0	CF	=	**4,266.7**	BCY	=	5,333.3 LCY
Total Excavation	=	180,900.0	CF					
Total Backfill of Excavation	=	180,900.0	CF	=	6,700.0	ECY	=	7,571.0 LCY

Canal Excavation

Includes excavation under levee but excludes the levee degrade (captured in next section below)

Length	=	650.0	FT	Length from L-67 canal to end of discharge canal
Total Depth	=	6.8	FT	Assume average depth of canal

Thickness of Organic	=	1.5	FT							
Thickness of Cap Rock	=	5.3	FT							
Slope1	=	2.0	:1							
Slope2	=	2.0	:1							
Bottom Width	=	40.0	FT							
Top Width	=	67.0	FT							
Cross Section	=	361.1	SF							
Cross Section Organic	=	96.0	SF							
Cross Section of Cap Rock	=	267.1	SF							
Surface Area of Canal	=	43,550.0	SF	=	1.0	ACRE				
Pete Organic	=	62,400.0	CF	=	**2,311.1**	BCY	=	2,888.9	LCY	
Cap Rock Volume	=	173,628.0	CF	=	**6,430.7**	BCY	=	9,646.0	LCY	
Haul road length	=	650.0	FT							
Haul road width	=	14.0	FT							
Haul road thickness	=	1.0	FT							

Levee Degrade (Degrade down to surface elevation canal/box culvert excavation captured above)

Length	=	175.0	FT							
Height	=	7.0	FT							
Slope1	=	2.0	:1							
Slope2	=	2.0	:1							
Top width	=	14.0	FT							
Bottom Width	=	42.0	FT							
Cross Section	=	196.0	SF							
Surface Area of Levee	=	13,406.7	SF	=	0.3	ACRE				
Volume	=	34,300.0	CF	=	**1,270.4**	BCY	=	1,588.0	LCY	
base area of levee	=	7,350.0	SF	=	816.7	SY	=	0.2	Acre	
side slopes of levee	=	10,956.7	SF	=	1,217.4	SY	=	0.3	Acre	
roadway area	=	2,450.0	SF	=	272.2	SY	=	0.1	Acre	

Inlet and Outlet Works

Number	=	4.0	EA	assumed intake/outlet are the same assumed 2 per each end gate and bulkhead
Foundation				

Length	=	8.0	FT						
Depth	=	5.0	FT						
Width	=	30.5	FT						
Volume	=	4,880.0	CF	=	180.7	CY			
Head Walls									
Height	=	20.5	FT						
Thickness	=	3.0	FT						
width	=	19.0	FT						
openings	=	121.0	SF						
volume	=	3,222.0	CF	=	119.3	CY			
End walls									
height	=	20.5	FT						
length	=	100.0	FT		total either inlet or outlet				
thickness	=	2.0	FT						
volume	=	8,200.0	CF	=	303.7	CY			
Railing	=	358.0	LF						
Ladders	=	2.0	EACH						
height	=	20.5	FT						
Gates IN HHD									
Height	=	14.0	FT		*** STAINLESS STEEL for opening 7 by 7				
Width	=	10.0	FT						
Weight	=	6,500.0	LB						
Weight Per SF	=	46.4	LB/SF						
NEW GATES									
number of gates	=	4.0	EA		assumed 2 on each end 1 gate and one bulkhead.				
Height	=	18.0	FT		assumed 4 ft larger than similar gate				
Width	=	14.0	FT		assumed 4 ft larger than similar gate				
Weight % larger	=	10.0	%		assumed				
Total Weight of gates	=	12,870.0	LB EA						
Motors	=	4.0	EA						
Gear Reduction	=	4.0	EA						
Actuators	=	4.0	EA						
cable reels	=	4.0	EA						
Imbeds for gate	=	138.0	LF						
Gate Seal Length	=	256.0	LF						
Operations building									
size	=	315.0	SF		8 by 8				
Electrical	=	NEEDED							
Communications	=	NEEDED							
Backfill									
Area above Culvert	=	180,900.0	CF	=	**6,700.0**	ECY	=	7,571.0	LCY
Levee Construction	=	34,300.0	CF	=	**1,270.4**	ECY	=	1,435.5	LCY
Cut off walls									
Number	=	1.0	EA		Assumed in FEB perimeter Levee				
Soil Bentonite Fill									

Height	=	25.0	FT				
Width	=	50.5	FT				
Thickness	=	8.0	FT				
Volume	=	10,100.0	CF/EA	=	374.1	CY/EA	
Cutoff Wall							
Height	=	35.0	FT				
Width	=	50.5	FT				
Thickness	=	3.0	FT				
Volume	=	5,302.5	CF/EA	=	196.4	CY/EA	
Area	=	1,767.5	SF/EA				

RIP RAP

common both sides							
number of placements	=	2.0	EA	1 each side			
Length	=	20.0	FT				
Width	=	30.5	FT				
thickness	=	4.0	FT				
Volume	=	2,440.0	CF/EA	=	90.4	CY/EA	
Total Volume	=	180.7	ECY	=	289.2	TON	

Boat Barrier

Number	=	2.0	EA				
Length	=	67.0	FT				
Total Length	=	134.0	FT				

SWPPP

Silt Fence	=	1,750.0	FT				

Site Fence

Length	=	1,000.0	FT	Assumed			
gates	=	4.0	FT	assumed			

Earthen Cofferdam

Length	=	350.0	FT	Assumed						
Cross Section	=	196.0	SF	ASSUMED SAME AS LEVEE DEGRADE						
Fill volume	=	68,600.0	CF	=	2,540.74	ECY	=	2,871.04	LCY	
removal volume	=	68,600.0	CF	=	2,540.74	BCY	=	3,175.9	LCY	

Feature of Work:	S-633 Gated Culvert 500 CFS GATED CULVERT IN L-67A LEVEE

Scope Given:	S-631 conveys flows from the WCA-3A to through the Blue Shanty Flow way to provide flows to the Shark River Slough

Reference for Scope Basis:	Engineering Appendix, March 2013, Section A.7.3.5, p. 112

Scope Assumptions:	- Assume similar to structures S-276 and S-277 contrary to the design guidance provided in the Engineering Appen paragraph A.7.4.4 which states "S-631, S-632, and S-633 are gated culverts that will be designed similar to the culverts on Decomp." Culvert is listed in Table A-29 as a single 11 ft x 11 ft concrete box culvert not multiple HDPE pipes. - Assume Levee and excavation quantities will be based on the profiles provided by the Decomp drawings and will correlate to the elevations given in the Engineering Appendix. - Assume an earthen cofferdam and rim ditch dewatering will be utilized to dewater the site. - Assume box culvert will be cast-in-place concrete. -Assume Excavation will be to the same depth below finished grade as shown in contract drawings for similar projects. Assume material as 1.5 ft of organic, 10 ft of Cap Rock and the remainder is inter-bedded material. - Assume a distribution canal will extend 500 ft beyond the discharge of the culvert and will taper from -4.5 ft NGV (Invert elevation) up to 9 ft NGVD (Natural Grade). Initial 150 ft will be lined with 3' of riprap and the new channel will have 1:2 side slopes. - Assume inlet channel will be excavated and will taper from -4.5 ft NGVD (Invert elevation) to 1.4 ft NGVD (Canal Bottom elevation). Assume inlet channel will have 1:2 side slopes and extend from the headwall to the existing channel (140 ft) and will be lined with 3'thick riprap that will extend 20 ft up and downstream L-67A Canal. - Assume power will be provided from power lines in the area approximately 3 miles. - Assume that a diesel generator is needed for backup power.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

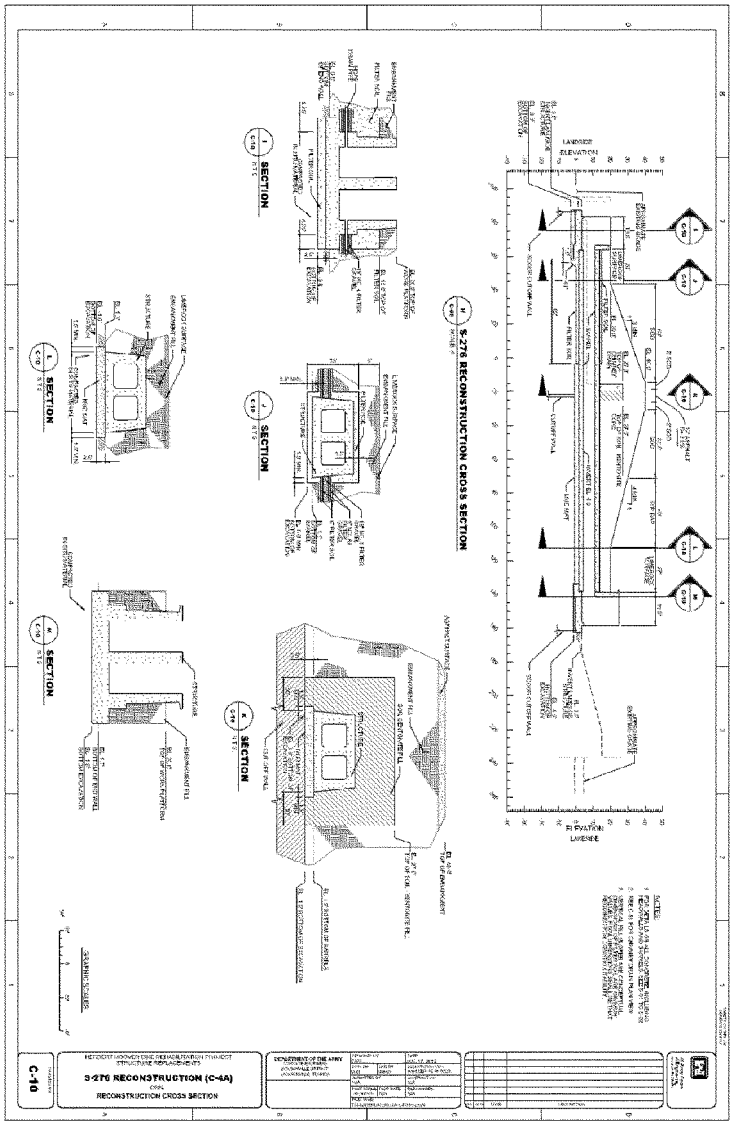
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope and assumptions were documented and sent to the design team for review. After reaching consensus on the scope and major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	Organic (muck) will be excavated and hauled off-site to a disposal facility. Cofferdam material will be imported to construct the cofferdam. Degrade levee and establish the earthen cofferdam around the inflow and outflow canal Excavated outflow canal and levee down to -7 ft NGVD to allow for installation of new box culvert, headwall and outlet/Gated structures with wing walls. Backfill levee to original cross section and line discharge canal with rip ra Remove cofferdam and excavate inlet channel and line with riprap to the existing L-67A Canal. Install emergency backup generator shelter and fuel tank pads and restore site.

Key Outstanding Questions/Issues:	Lacks details on motors needed to operate gate. Lacks details on source of power for said motors.

Representative Drawings/Photos: S-633



Feature of Work:	S-633 Gated Culvert 500 CFS GATED CULVERT IN L-67A LEVEE

Quantity Take Off:

Culvert Excavation

Thickness of Organic	=	1.5	FT					
Thickness of Cap Rock	=	3.0	FT					
Total depth	=	4.5	FT					
bottom width	=	58.0	FT					
Length	=	600.0	FT					
Slope of Excavation	=	2.0	:1					
Top Width of Excavation	=	76.0	FT					
Excavation of Organic	=	109.5	SF					
Excavation of Cap Rock	=	192.0	SF					
Volume of Organic	=	65,700.0	CF	=	**2,433.3**	BCY	=	3,041.7 LCY
Volume of Cap Rock	=	115,200.0	CF	=	**4,266.7**	BCY	=	5,333.3 LCY
Total Excavation	=	180,900.0	CF					
Total Backfill of Excavation	=	180,900.0	CF	=	6,700.0	ECY	=	7,571.0 LCY

Canal Excavation

Includes excavation under levee but excludes the levee degrade (captured in next section below)

Length	=	650.0	FT	Length from L-67 canal to end of discharge canal
Total Depth	=	6.8	FT	Assume average depth of canal

Thickness of Organic	=	1.5	FT							
Thickness of Cap Rock	=	5.3	FT							
Slope1	=	2.0	:1							
Slope2	=	2.0	:1							
Bottom Width	=	40.0	FT							
Top Width	=	67.0	FT							
Cross Section	=	361.1	SF							
Cross Section Organic	=	96.0	SF							
Cross Section of Cap Rock	=	267.1	SF							
Surface Area of Canal	=	43,550.0	SF	=	1.0	ACRE				
Pete Organic	=	62,400.0	CF	=	**2,311.1**	BCY	=	2,888.9	LCY	
Cap Rock Volume	=	173,628.0	CF	=	**6,430.7**	BCY	=	9,646.0	LCY	
Haul road length	=	650.0	FT							
Haul road width	=	14.0	FT							
Haul road thickness	=	1.0	FT							

Levee Degrade (Degrade down to surface elevation canal/box culvert excavation captured above)

Length	=	175.0	FT							
Height	=	7.0	FT							
Slope1	=	2.0	:1							
Slope2	=	2.0	:1							
Top width	=	14.0	FT							
Bottom Width	=	42.0	FT							
Cross Section	=	196.0	SF							
Surface Area of Levee	=	13,406.7	SF	=	0.3	ACRE				
Volume	=	34,300.0	CF	=	**1,270.4**	BCY	=	1,588.0	LCY	
base area of levee	=	7,350.0	SF	=	816.7	SY	=	0.2	Acre	
side slopes of levee	=	10,956.7	SF	=	1,217.4	SY	=	0.3	Acre	
roadway area	=	2,450.0	SF	=	272.2	SY	=	0.1	Acre	

Inlet and Outlet Works

Number	=	4.0	EA	assumed intake/outlet are the same assumed 2 per each end gate and bulkhead
Foundation				

Length	=	8.0	FT						
Depth	=	5.0	FT						
Width	=	30.5	FT						
Volume	=	4,880.0	CF	=	180.7	CY			
Head Walls									
Height	=	20.5	FT						
Thickness	=	3.0	FT						
width	=	19.0	FT						
openings	=	121.0	SF						
volume	=	3,222.0	CF	=	119.3	CY			
End walls									
height	=	20.5	FT						
length	=	100.0	FT		total either inlet or outlet				
thickness	=	2.0	FT						
volume	=	8,200.0	CF	=	303.7	CY			
Railing	=	358.0	LF						
Ladders	=	2.0	EACH						
height	=	20.5	FT						
Gates IN HHD									
Height	=	14.0	FT		*** STAINLESS STEEL for opening 7 by 7				
Width	=	10.0	FT						
Weight	=	6,500.0	LB						
Weight Per SF	=	46.4	LB/SF						
NEW GATES									
number of gates	=	4.0	EA		assumed 2 on each end 1 gate and one bulkhead.				
Height	=	18.0	FT		assumed 4 ft larger than similar gate				
Width	=	14.0	FT		assumed 4 ft larger than similar gate				
Weight % larger	=	10.0	%		assumed				
Total Weight of gates	=	12,870.0	LB EA						
Motors	=	4.0	EA						
Gear Reduction	=	4.0	EA						
Actuators	=	4.0	EA						
cable reels	=	4.0	EA						
Imbeds for gate	=	138.0	LF						
Gate Seal Length	=	256.0	LF						
Operations building									
size	=	315.0	SF		8 by 8				
Electrical	=	NEEDED							
Communications	=	NEEDED							
Backfill									
Area above Culvert	=	180,900.0	CF	=	**6,700.0**	ECY	=	7,571.0	LCY
Levee Construction	=	34,300.0	CF	=	**1,270.4**	ECY	=	1,435.5	LCY
Cut off walls									
Number	=	1.0	EA		Assumed in FEB perimeter Levee				
Soil Bentonite Fill									

Height	=	25.0	FT				
Width	=	50.5	FT				
Thickness	=	8.0	FT				
Volume	=	10,100.0	CF/EA	=	374.1	CY/EA	
Cutoff Wall							
Height	=	35.0	FT				
Width	=	50.5	FT				
Thickness	=	3.0	FT				
Volume	=	5,302.5	CF/EA	=	196.4	CY/EA	
Area	=	1,767.5	SF/EA				

RIP RAP

common both sides							
number of placements	=	2.0	EA	1 each side			
Length	=	20.0	FT				
Width	=	30.5	FT				
thickness	=	4.0	FT				
Volume	=	2,440.0	CF/EA	=	90.4	CY/EA	
Total Volume	=	180.7	ECY	=	289.2	TON	

Boat Barrier

Number	=	2.0	EA				
Length	=	67.0	FT				
Total Length	=	134.0	FT				

SWPPP

Silt Fence	=	1,750.0	FT				

Site Fence

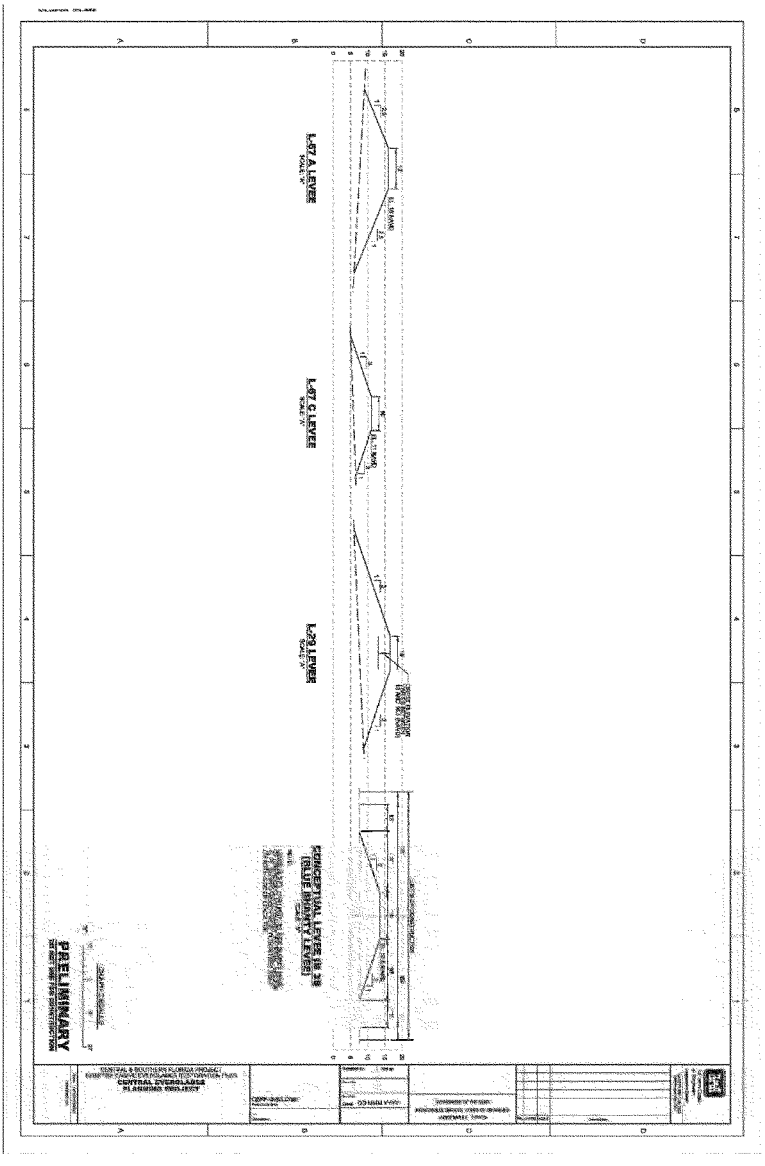
Length	=	1,000.0	FT	Assumed			
gates	=	4.0	FT	assumed			

Earthen Cofferdam

Length	=	350.0	FT	Assumed						
Cross Section	=	196.0	SF	ASSUMED SAME AS LEVEE DEGRADE						
Fill volume	=	68,600.0	CF	=	2,540.74	ECY	=	2,871.04	LCY	
removal volume	=	68,600.0	CF	=	2,540.74	BCY	=	3,175.9	LCY	

Feature of Work:	GAP LEVEE L-67C FOR ~6000 LF
Scope Given:	Degrade 6000 feet of L-67C just east of L-67D and export material.
Reference for Scope Basis:	Engineering Appendix, March 2013
Scope Assumptions:	- Assume levee cross section is 10 ft wide top, 5 ft tall (10ft NGVD and Ground elevation 5 ft NGVD) with 3:1 side slopes for the entire 6000 LF length per Annex C2. Assume that top 6 in of material on levee is unsuitable and will be hauled to a disposal site. - Assume that all material coming from the levee will need processing prior to reuse as backfill.
Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope and assumptions were documented and sent to the design team for review. After reaching consensus on the scope and major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.
Sequence of Work:	- Survey site and stake entire length of canal. - Install floating turbidity boom and silt fence along the entire length of the canal. Floating turbidity boom and silt fence maintenance will be ongoing during construction of the canal. Maintenance of existing levee access road will be on going throughout construction. - Clear and grub entire site to remove vegetation and organic materials. Haul to disposal location. - Excavate levee haul to processing. - Place Riprap on ends of excavated levee.
Key Outstanding Questions/Issues:	

Representative Drawings/Photos: L-67C Gap



Feature of Work:	GAP LEVEE L-67C FOR ~6000 LF

Quantity Take Off:

Levee Removal

Length	=	6000.0	FT			1.14	Miles	=	6000	FT
Height	=	5.0	FT							
Slope1	=	3.0	:1							
Slope2	=	3.0	:1							
Top width	=	10.0	FT							
Bottom Width	=	40.0	FT							
Unsuitable Material	=	0.5	FT							
Cross Section	=	125.0	SF							
Surface Area of Levee	=	439,473.3	SF	=	10.1	ACRE				
base area of levee	=	240,000.0	SF	=	26,666.7	SY	=	5.5	Acre	
side slopes of levee	=	379,473.3	SF	=	42,163.7	SY	=	8.7	Acre	
roadway area	=	60,000.0	SF	=	6,666.7	SY	=	1.4	Acre	
volume of unsuitable	=	219,736.7	CF	=	8,138.4	BCY	=	10,173	LCY	
usable volume	=	530,263.3	CF	=	19,639.4	BCY	=	24,549	LCY	
Total Volume	=	750,000.0	CF	=	27,777.8	BCY				

Feature of Work:	L-67D NEW LEVEE IN WCA 3B

Scope Given:	L-67D is a new levee in WCA 3B. L-67D is approximately 8.5 miles long and connects from L-67A to L-29. It has a 14 crest width, 3:1 side slopes, and is 6 ft high.

Reference for Scope Basis:	Engineering Appendix, March 2013, Table A-1, p. 10

Scope Assumptions:	- Assumed material must be removed to the level of the rippable rock to allow for a stable levee foundation. - Assumed side slopes of excavation at a 1:2 slope. Assumed the excavated area will be backfilled with levee material. - Assume 6 ft of organic material will be removed and re-spread on the constructed levee. - Assumed Plantings: All plantings on levees will be native grasses.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

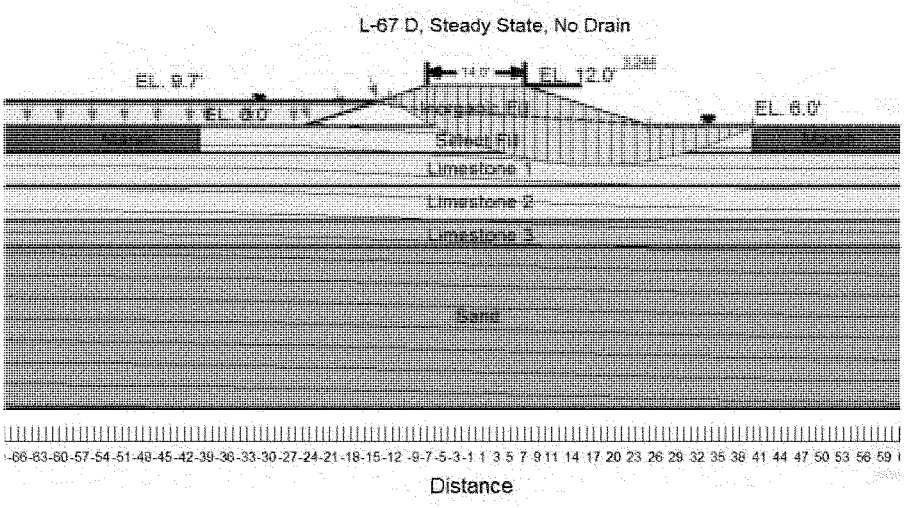
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope and assumptions were documented and sent to the design team for review. After reaching consensus on the scope and major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	- Site survey and stake entire length and width of Levee. - Silt Fence the entire site. Silt fence maintenance will be ongoing during construction of the Levee. - Clear and grub entire site to remove vegetation and organic materials. Organic materials will be stockpiled on site to be spread as dressing on the new levee.. - Excavate Common Material to rock depth. Common material will be hauled to on site processing plant assumed side slopes of excavation at 1V:2H. - Build Levee compacting in 6-12 inch lifts hauling processed material from processing plant to levee location. - Plant Grasses on side slopes.

Key Outstanding Questions/Issues:	

Representative Drawings/Photos: L-67D



Feature of Work: L-67D NEW LEVEE IN WCA 3B

Quantity Take Off:

Levee Construction

Length	=	44,880.0	FT			8.5	Miles	=	44,880.0	FT
Height	=	6.0	FT							
Slope1	=	3.0	:1							
Slope2	=	3.0	:1							
Top width	=	14.0	FT							
Bottom Width	=	50.0	FT							
Cross Section	=	192.0	SF							
Surface Area of Levee	=	4,602,164.6	SF	=		105.7	ACRE			
Volume	=	8,616,960.0	CF	=		**319,146.7**	ECY	=	360,635.7	LCY
base area of levee	=	2,244,000.0	SF	=		249,333.3	SY	=	51.5	Acre
side slopes of levee	=	3,973,844.6	SF	=		441,538.3	SY	=	91.2	Acre

Levee Sub Surface Excavation

Thickness of Organic	=	6.0	FT							
Total depth	=	6.0	FT							
bottom width	=	86.0	FT							
Slope of Excavation	=	2.0	:1							
Top Width of Excavation	=	110.0	FT							
Excavation of Organic	=	588.0	SF							
Volume of Organic	=	26,389,440.0	CF	=		**977,386.7**	BCY	=	1,221,733.3	LCY
Total Excavation	=	26,389,440.0	CF							
Total Backfill of Excavation	=	26,389,440.0	CF	=		**977,386.7**	ECY	=	1,104,446.9	LCY

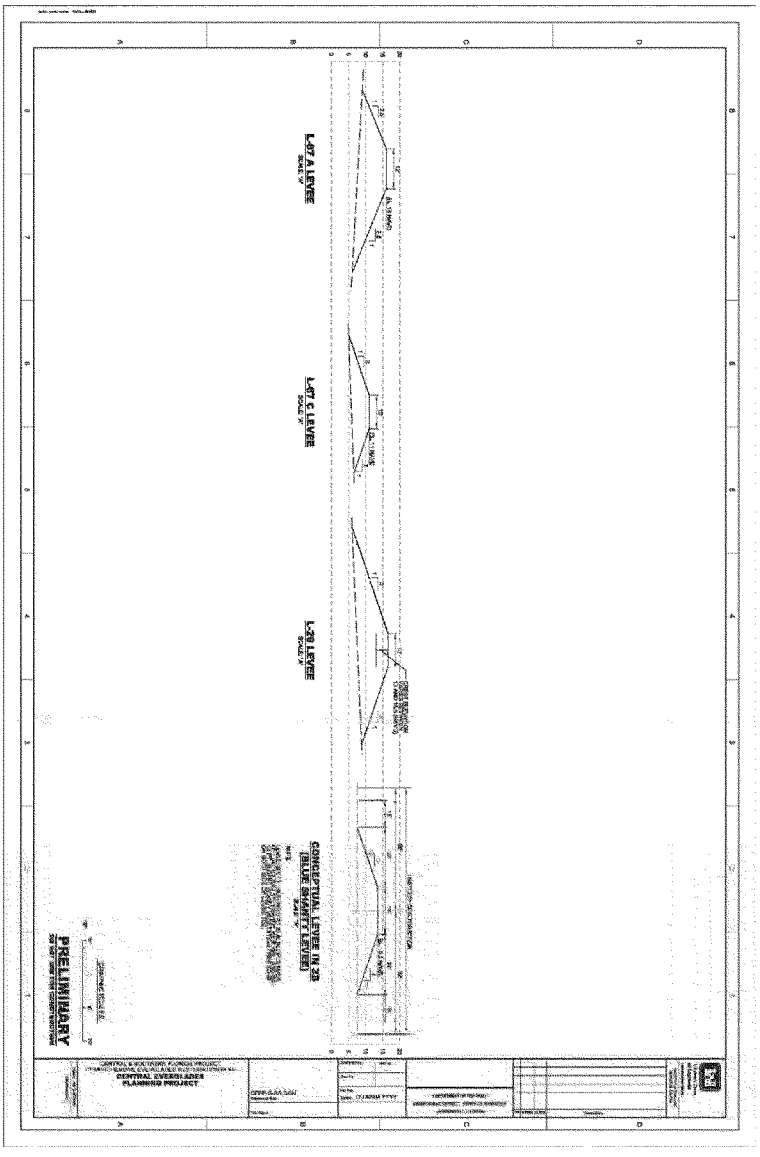
Site Restoration

area next to levees	=	2,692,800.0	SF	=		299,200.0	SY			
Road length	=	44,880.0	FT							
Road width	=	14.0	FT							
minimum thickness	=	0.5	FT							
Volume to Remove	=	11,635.6	BCY	=		14,544.4	LCY			

Feature of Work:	LEVEE REMOVAL OF ~8 MILES OF L-67C LEVEE

Scope Given:	The levee removal of 8 miles from L-67C levee south to intersection of L-67A/L-67C for new 3B Levee. L-67C canal i not backfilled.
Reference for Scope Basis:	Engineering Appendix, March 2013, Table A-1, p. 10
Scope Assumptions:	- Assume levee cross section is 10 ft wide top, 5 ft tall (10ft NGVD and Ground elevation 5 ft NGVD) with 3:1 side slopes for the entire 8 Mile length. - Assume that top 0.5 ft of material on levee is unsuitable and will be hauled to a disposal site. - Assume that all material coming from the levee will need processing prior to reuse as backfill.
Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.
Sequence of Work:	- Survey site and stake entire length of canal. - Install floating turbidity boom and silt fence along the entire length of the canal. Floating turbidity boom and silt fence maintenance will be ongoing during construction of the canal. Maintenance of existing levee access road will be on going throughout construction. - Clear and grub entire site to remove vegetation and organic materials. Haul to disposal location. - Excavate levee haul to processing. - Place Riprap on ends of excavated levee.
Key Outstanding Questions/Issues:	

Representative Drawings/Photos: L-67C Removal



Feature of Work: LEVEE REMOVAL OF ~8 MILES OF L-67C LEVEE

Quantity Take Off:

Levee Removal

Length	=	42240.0	FT			8.0	Miles	=	42240 FT
Height	=	5.0	FT						
Slope1	=	3.0	:1						
Slope2	=	3.0	:1						
Top width	=	10.0	FT						
Bottom Width	=	40.0	FT						
Unsuitable Material	=	0.5	FT						
Cross Section	=	125.0	SF						
Surface Area of Levee	=	3,093,892.2	SF	=	71.0	ACRE			
base area of levee	=	1,689,600.0	SF	=	187,733.3	SY	=	38.8	Acre
side slopes of levee	=	2,671,492.2	SF	=	296,832.5	SY	=	61.3	Acre
roadway area	=	422,400.0	SF	=	46,933.3	SY	=	9.7	Acre
volume of unsuitable	=	1,546,946.1	CF	=	57,294.3	BCY	=	71,618	LCY
usable volume	=	3,733,053.9	CF	=	138,261.3	BCY	=	172,827	LCY
Total Volume	=	5,280,000.0	CF	=	195,555.6	BCY			

Feature of Work:	S-355W - Gated Spillway 1230 CFS In L29 Canal, East of L67 D

Scope Given:	The S-355W structure is a gated spillway located at the southern extent of the proposed L-67D levee. The purpose the S-355W is to convey water from the L-29 Canal within the Blue Shanty Flow way, eastward towards the existing 334 spillway to provide assistance in meeting ENP ecological objectives. The structure is a three-bay gated spillway with a design capacity of 1,230 cfs and hydraulic head of 1.0 foot. The design flow was set to match the capacity of 334. The spillway consists of three bays with dimensions of 12 ft wide by 8 ft high. The crest invert elevation is set t 4.00 ft NGVD. The upstream and downstream aprons are set at elevation -4.00 ft NGVD with a width and length of 36.0 feet and 42.5 feet, respectively.

Reference for Scope Basis:	Engineering Appendix, March 2013 Table A-31 A.7.4.3 Overflow Spillways A.7.3.3.2.1.2 Gated Spillways

Scope Assumptions:	- Assume similar to structure S-65EX. - Assume given dimensions in the engineering appendix govern over provided design documents for similar structu if no dimensions are given in the engineering appendix all dimensions will come from the similar structure. - Assume aprons are in addition to the concrete structure shown in the provided drawings. - Assume power for the structure will be provided from local power lines located .5 miles from the structure. - Assume Structure will be constructed in two phases and not require a bypass canal. - Assume 0 ft of organic material, 7.5 ft of cap rock requiring blasting and the remainder will be inter-bedded material. - Assume 50 ft deep sheet pile 1000 ft long. - Assume dimensions of existing canal L-29 canal, top width 140 ft, bottom width, 50 ft, 22.5 ft deep with side slopı of 1:2. - Assume dewatering will be ongoing through feature of work utilizing rim ditch dewatering - Assume 35 KW Diesel Generator with 1000 gallon above ground tank.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

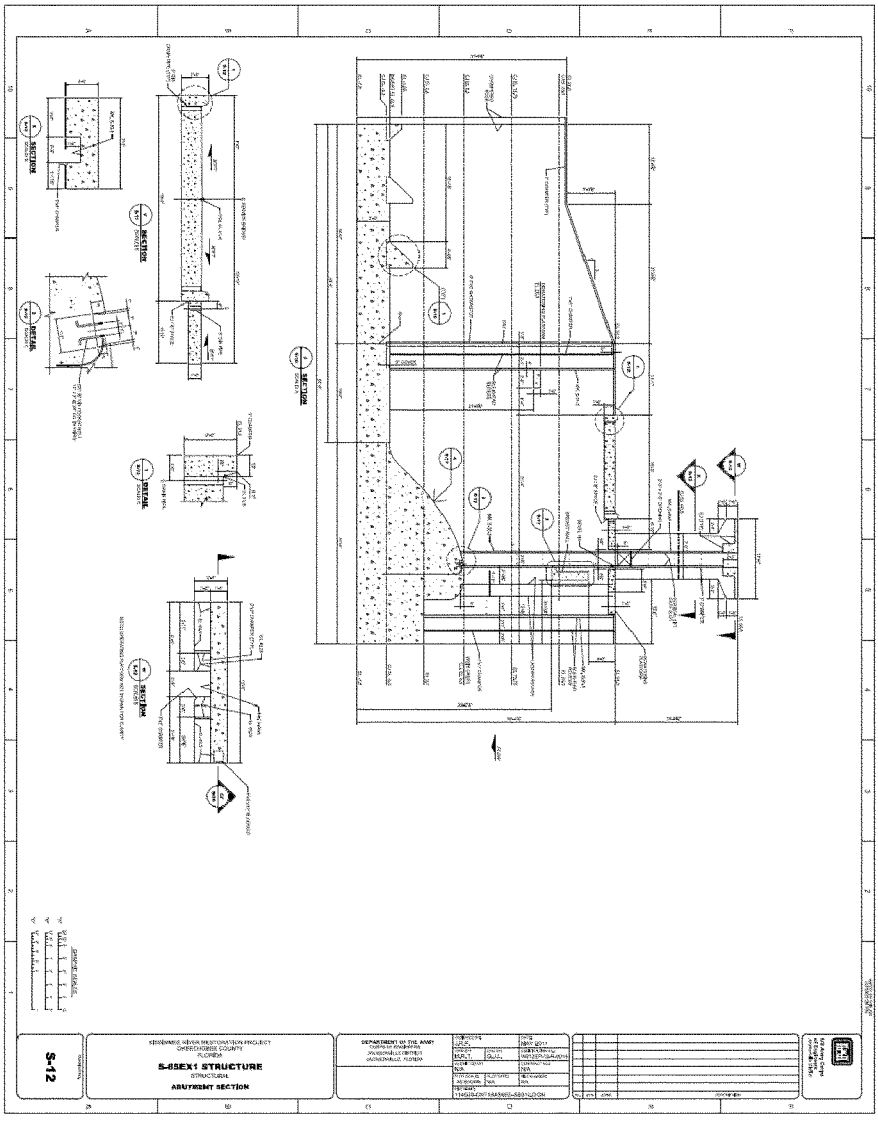
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	- Sheet pile will be installed to work on each of the two phases of construction working from the north to the soutl - Excavation of materials to allow for construction of the foundation of the cross canal gate structure and the canal apron/wing wall. Construction of concrete work for structure followed by apron and wing walls. Backfill suitable material around the structure and import riprap. Construct control station, diesel generator, and fuel storage. Pla gates and other associated closure devices for the gate structure.

Key Outstanding Questions/Issues:	

Representative Drawings/Photos: S-355W Gated Spillway 1230 CFS



Feature of Work:	DISTRIBUTION - LEVEE REMOVAL OF L67C FOR NEW 3B LEVEE

Quantity Take Off:

Structure Dimensions and volumes

Underwater Concrete Seal Volume (Unreinforced	=	3,318.5	CY	Underwater concrete is not reinforced, 10 ft thick 56 ft wide and 160 ft long			
Number of Gates	=	3.0	EA				
tower cross section	=	144.9	SF				
number of towers	=	4.0	EA				
pier cross section	=	154.1	SF				
number of Piers	=	2.0	EA				
tower width	=	3.5	FT				
Pier Height	=	35.0	FT				
beam cross section	=	15.0	SF				
volume of elevated beam	=	540.0	CF	=	20.0	CY	
OGEE volume							
OGEE Spillway volume	=	5,180.4	CF	=	191.9	CY	
Spillway wall volume (Abutment)	=	1,153.3	CY	Structure is 90' long and cross section of wall is 173 SF			
Approach apron	=	283.3	CY	Assumed 36ft long 42.5 ft wide and 5 ft thick per S-65EX design			
Stilling Basin	=	283.3	CY	Assumed 36ft long 42.5 ft wide and 5 ft thick per S-65EX design			

Wing Walls Assumed approach wing walls similar to downstream wing wall plan from S-65EX-1 with anchor walls. Construction will consist of driven sheet pile with a 2'x2' concrete pile cap. The anchor walls will be 1 ft thick reinforced concrete. Concrete anchor wall dimensions will match wing wall dimensions. The wing wall and concrete anchor wall will be connected by #10 all thread grade 70. A C8x18.75 channel will be attached to the back of the wing wall where the anchors will be attached to.

wing walls							
Number	=	4.0	Each				
Length average US and DS	=	95.5	FT				
US Depth	=	44.5	FT				
DS Depth	=	26.5	FT				
area of sheet pile	=	13,561.0	SF				
Pile Cap							
height	=	2.0	FT				
width	=	2.0	FT				
volume	=	56.6	CY				
Rod length	=	60.0	FT				
spacing	=	4.0	FT				
number of rods	=	96.0	EA	total length	=	5,760.0	FT
Anchor Walls							
height	=	8.0	FT				
thickness	=	1.0	FT				
length	=	382.0	FT				
volume	=	113.2	CY				

Rip Rap				Lengths and depths assumed to extend beyond aprons.
Length	=	440.0	FT	
width	=	36.0	FT	
Depth	=	3.0	FT	average of all depths
volume	=	1,760.0	CY	

Excavation for Footing Volume	=	89,600.0	CF	Assume 56' wide (per width of channel) by 60 ft long (per S-65EX)
	=	**3,318.5**	BCY	and 10' deep to allow for construction of the underwater seal and
	=	4,977.8	LCY	structural footings. Assume bottom of canal requires blasting to remove rock.
Excavation east and west	=	108,000.0	CF	Total depth 22.5'. Assume excavation is 160 ft long and extends the
canal banks for installation of	=	**4,000.0**	BCY	bottom of the canal an additional 15' per bank. Assume material is
	=	6,000.0	LCY	common or rippable as it is the bank of a levee.
Sheet pile/cofferdam	=	1,000.0	LF	Assume 1000 LF of sheet pile/cofferdam to go around entire work
Area	=	60,000.0	SF	site. Sheet pile will be driven 60ft deep. All sheet pile used as a coffer dam will be removed.

Gate weight calculations

3/8" Plate steel	=	15.3	lb/sq ft			
1/2" Plate steel	=	20.4	lb/sq ft			
1" Plate Steel	=	40.8	lb/sq ft			
Gate Skin 3/8" Plate Steel	=	392.0	sq ft	Assume Gate dimensions of 14'x28'		
3/8" Plate stiffeners and seal angles	=	87.0	sq ft	Assume 5 sq ft for seal angles and 82 for stiffeners		
Horizontal C-Channels (1/2")	=	607.0	sq ft	Assume each channel is equivalent to 26"x28' (10 Channels).		
Vertical C-Channels	=	303.0	sq ft	Assume each vertical channel is 26"x14' (10 Channels).		
Pull Pad eyes (1")	=	4.0	sq ft	Assume 4 pad eyes per gate @ 1 sq ft each		
Total 3/8" Plus 10% for misc. items	=	526.9	sq ft	=	8,061.6	lbs
Total 1/2" plus 15% for misc items	=	1,046.5	sq ft	=	21,348.6	lbs
Total 1" steel	=	4.0	sq ft	=	163.2	lbs
lbs/sq ft for 28'x14' gate	=	75.4	lb/sq ft			
Area of single S-355W Gate	=	165.0	sq ft	assumed 3 ft bigger then opening in each direction		
Approximate weight of S-355W Gate	=	12,448.0	lb			
Overweight factor for larger gates (10%)	=	13,692.8	LB EA	total of 3 needed.		

Precast Concrete Control Building / Generator Shelter

Shelter square footage	=	315.0	sq ft	Assume Shelter will be 10' tall and have a 8" concrete block partition wall full height. Assume one 4'-4" steel door and one 3'-4" door. Assume 4 3' x 5' Louvers along with a generator radiator
Excavation/backfill for shelter	=	163.3	ECY	Building will be set on grade with 12" capillary water barrier and geotextile fabric and a 12" thick concrete curb around the building
Generator Fuel Tank	=	1000 Gallon		
Fuel Pad dimensions	=	96.0	SF	Assume 8'x12'x12" thick reinforced concrete slab on grade pad.

Gate embeds/seal lengths

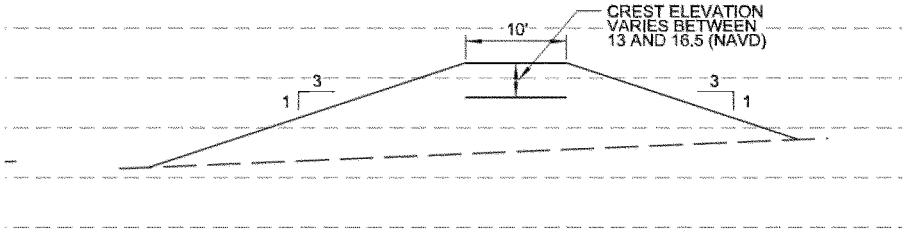
Gate Dimensions						
Width	=	15.0	FT			
Height	=	11.0	FT			
Gate well Height	=	42.0	FT			
Gate Well Embed	=	99.0	FT			
Total Embed length	=	297.0	FT	3 gates		
Seal Length	=	52.0	FT	seal length is the perimeter of bottom and both sides.		
Total Seal length	=	156.0	FT	total of 3 gates		
Up and Downstream Bulkhead Slot	=	588.0	FT	6 times vertical plus width of new gate per slot		
Bulkheads	=	13,692.8	LB EA	assume same size as gates		
number	=	6.0	EA	two per gate needed		
Total Length of imbeds	=	885.0	FT			
Total Weight of gates and stop logs	=	123,234.9	LB	=	61.6	TON

TOTAL J BULB for GATES AND STOP LOGS	=	468.0	FT			
Backfill						
Backfill around structures	=	**4,000.0**	ECY	=	4,520.00	LCY
Removal of Sheet Pile	=	1,000.0	LF		@ 60 ft deep	
Area	=	60,000.0	SF			
Railings and ladders						
Railing						
Length	=	760.0	FT		assumed 4 time the length of a wing wall and 6 times the width	
Height	=	3.5	FT		of the structure and twice the length	
Ladders						
Count	=	6.0	EA		assumed ladders on each side of the structure.	
Height	=	17.5	FT		average of all three types	
total height	=	105.0	FT			
Boat Barrier						
Number	=	2.0	EA			
Length each	=	142.0	FT			
Total Length	=	284.0	FT			
Site Fencing						
Length	=	1,000.0	FT		assumed a total of 1000 LF of chain link fencing.	
Gates	=	4.0	EA		assumed	
Access road						
Length	=	300.0	FT		assumed	
Width	=	14.0	FT		assumed	
Area	=	4,200.0	SF	=	466.7	SY
SWPPP						
Length	=	800.0	LF			
Floating Silt Boom	=	600.0	LF			

Feature of Work:	LEVEE REMOVAL OF L-29

Scope Given:	The levee removal of 4.3 miles from ValuJet monument to L-67D levee intersection with L-29 levee.
Reference for Scope Basis:	Engineering Appendix, March 2013, Table A-1, A.7.2 GEOTECHNICAL DESIGN, ANNEX C2. CIVIL PLATES
Scope Assumptions:	- Assume that top 0.5 ft of material on levee is unsuitable and will be hauled to a disposal site. - Assume that all material coming from the levee will need processing prior to reuse as backfill. - Assume top width is 10 ft, base elevation of 6 ft NAVD and average crest elevation of 16 ft NAVD.
Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.
Sequence of Work:	- Survey site and stake entire length of levee. - Install floating turbidity boom and silt fence along the entire length of the canal. Floating turbidity boom and silt fence maintenance will be ongoing during construction. Maintenance of existing levee access road will be on going throughout construction. - Clear and grub entire site to remove vegetation and organic materials. Haul to disposal location. - Excavate levee haul to processing. - Place Riprap on ends of excavated levee.
Key Outstanding Questions/Issues:	

Representative Drawings/Photos: Levee Removal of L-29



L-29 LEVEE

SCALE: "A"

Feature of Work: LEVEE REMOVAL OF L-29

Quantity Take Off:

Levee Removal

Length	=	22704.0	FT			4.3	Miles =	=	22704	FT
Height	=	10.00	FT							
Slope1	=	3.0	:1							
Slope2	=	3.0	:1							
Top width	=	10.0	FT							
Bottom Width	=	70.0	FT							
Unsuitable Material	=	0.5	FT							
Cross Section	=	400.0	SF							
Surface Area of Levee	=	1,662,967.0	SF	=	38.2	ACRE				
base area of levee	=	1,589,280.0	SF	=	176,586.7	SY	=	36.5	Acre	
side slopes of levee	=	1,435,927.0	SF	=	159,547.4	SY	=	33.0	Acre	
roadway area	=	227,040.0	SF	=	25,226.7	SY	=	5.2	Acre	
volume of unsuitable	=	831,483.5	CF	=	30,795.7	BCY	=	38,495	LCY	
usable volume	=	8,250,116.5	CF	=	305,559.9	BCY	=	381,950	LCY	
Total Volume	=	9,081,600.0	CF	=	336,355.6	BCY				

Feature of Work:	ROAD REMOVAL OF TAMIAMI TRAIL

Scope Given:	Remove approximately 6 miles of Old Tamiami Trail between the Everglades National Park (ENP) Tram Road and th L-67 Extension Levee.

Reference for Scope Basis:	Engineering Appendix, March 2013, Section A-2, p. 8

Scope Assumptions:	- Assume road is covered with 3 inches of asphalt. - Assume road width is 30 FT. - Assume height of road is 5 ft above natural grade with side slopes of 2:1. - Assume power lines will have to be relocated along the current Tamiami Trail. - Assume that all material coming from the levee will need processing prior to reuse as backfill. - Assume all asphalt is hauled off site to disposal. - Assume dense vegetation on the side slopes of the road will need to be removed.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	- Site survey and stake entire area of the road removal. - Silt Fence and floating turbidity boom the entire site. Silt fence and floating turbidity boom maintenance will be ongoing during construction. - Install new power lines along the Current alignment of the Tamiami Trail. - Remove existing power lines along the old Tamiami Trail. - Remove asphalt and haul to offsite disposal. - Remove road prism and haul to processing.

Key Outstanding Questions/Issues:	No information for dimensions of road (depth, width, material, etc.) and no information on extent of road removal was provided.

Representative Drawings/Photos: Road Removal of Tamiami Trail

Feature of Work: ROAD REMOVAL OF TAMIAMI TRAIL

Quantity Take Off:

Road Way Removal

Length	=	31,680.0	FT		6.0	Miles	=	31,680.0	FT
Height	=	5.0	FT						
Slope1	=	2.0	:1						
Slope2	=	2.0	:1						
Top width	=	30.0	FT						
Bottom Width	=	50.0	FT						
Cross Section	=	200.0	SF						
Surface Area of Prism	=	5,200,718.0	SF	=	119.4	ACRE			
Volume	=	6,336,000.0	CF	=	**234,666.7**	BCY	=	293,333.3	LCY
base area of Prism	=	1,584,000.0	SF	=	176,000.0	SY	=	36.4	Acre
side slopes of Prism	=	4,250,318.0	SF	=	472,257.6	SY	=	97.6	Acre
roadway area	=	950,400.0	SF	=	105,600.0	SY	=	21.8	Acre
Asphalt Thickness	=	3.0	IN						
Asphalt Volume	=	237,600.0	CF	=	8,800.0	BCY			

Feature of Work:	DEGRADE LEVEE L-67 EXTENSION FOR 5.5 MILE SECTION

Scope Given:	Complete removal of approximately 5.5 miles of L-67 Extension Levee. The material removed from the L-67 Extens Levee will then be used to backfill the L-67 Extension Canal.

Reference for Scope Basis:	Engineering Appendix, March 2013, Table A-1, p. 11

Scope Assumptions:	- Assume Height of levee is 8 ft top width of levee is 10 ft side slopes of levee are 3:1. - Assume canal dimensions will allow for full disposal of levee. - Assumed 35 ft between canal and levee western toe. - Assume that no processing will be required prior to placing into the canal. - Assume no compaction of material required.

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	- Site survey and stake entire area of the levee removal. - Silt Fence and floating turbidity boom the entire site. Silt fence and floating turbidity boom maintenance will be ongoing during construction. - Excavate levee and back fill canal. Material will be piled in the canal and allowed to settle. - Plant native vegetation, remove silt fence and survey site.

Key Outstanding Questions/Issues:	No dimensions of levee to be degraded and no dimensions of canal to be filled were given.

Representative Drawings/Photos: Degrade L-67 EXT

Feature of Work:	DEGRADE LEVEE L-67 EXTENSION FOR 5.5 MILE SECTION

Quantity Take Off:

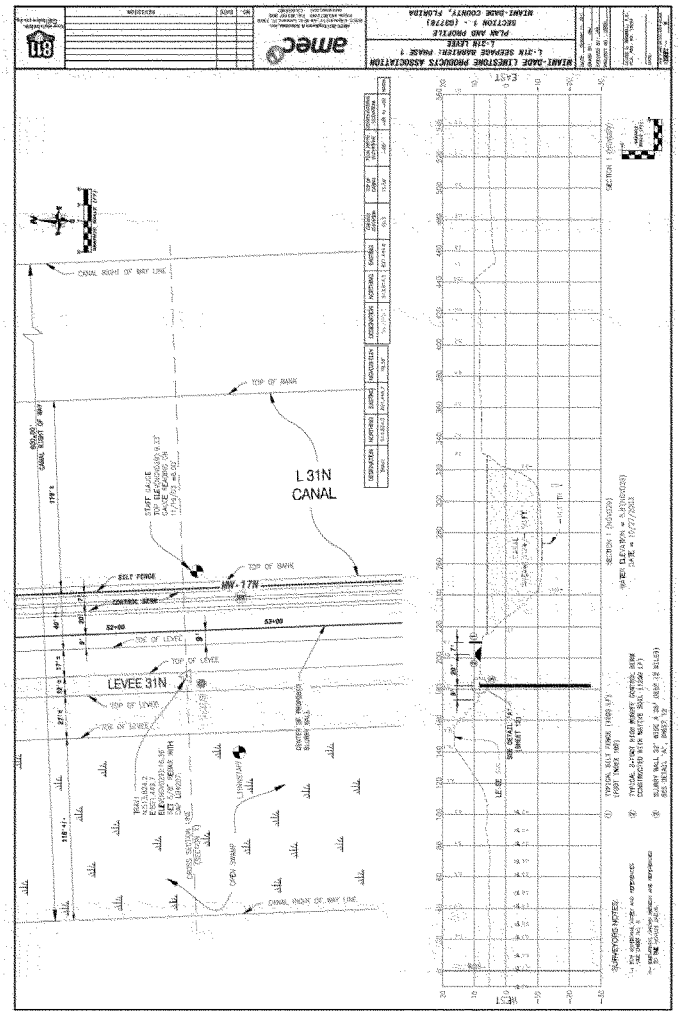
Levee Removal or Construction

Length	=	29,040.0 FT			5.5 Mi	29040.00 FT
Height	=	8.0 FT				
Slope1	=	3.0 :1				
Slope2	=	3.0 :1				
Top width	=	10.0 FT				
Bottom Width	=	58.0 FT				
Cross Section	=	272.0 SF				
Surface Area of Levee	=	2,068,970.9 SF	=	47.5 ACRE		
Volume	=	7,898,880.0 CF	=	**292,551.1** BCY	=	365,688.9 LCY
base area of levee	=	1,684,320.0 SF	=	187,146.7 SY	=	38.67 Acre
side slopes of levee	=	1,836,650.9 SF	=	204,072.3 SY	=	42.16 Acre
roadway area	=	290,400.0 SF	=	32,266.7 SY	=	6.67 Acre

Feature of Work:	SEEPAGE BARRIER CUTOFF WALL IN L-31N LEVEE

Scope Given:	Construct a seepage barrier cutoff wall in the L-31N Levee just south of the Tamiami Trail. The Wall will be made from Soil Cement Bentonite (SCB) and approximately 3.5 miles long, 3 feet wide, and 35 feet deep.
Reference for Scope Basis:	Engineering Appendix, March 2013, Table A-1, p. 11
Scope Assumptions:	- Assume similar to structure L-31N Seepage Barrier – Phase 1. - Assume given dimensions in the engineering appendix govern over provided design documents for similar structu If no dimensions are given in the engineering appendix all dimensions will come from the similar structure.
Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.
Sequence of Work:	- Site survey and stake entire area of the cutoff wall. - Silt Fence and floating turbidity boom the entire site. Silt fence and floating turbidity boom maintenance will be ongoing during construction. - Install Monitoring Wells. - Install soil-cement-Bentonite wall, backfill and compact top of wall and plant with native grasses.
Key Outstanding Questions/Issues:	

Representative Drawings/Photos: Seepage Barrier Cutoff Wall in L-31N



Feature of Work: SEEPAGE BARRIER CUTOFF WALL IN L-31N LEVEE

Quantity Take Off:

Seepage Cut Off							
Length	=	22,176.0	FT				
Depth	=	35.0	FT				
thickness	=	3.0	FT				
Area of wall	=	776,160.0	SF				
volume of wall	=	2,328,480.0	CF	=	86,240.0	BCY	
Borings							
Spacing	=	200.0	FT				
Number per spacing	=	1.0	EA				
total number needed	=	111.0	EA				
Depth	=	35.0	FT		assumed full depth		
Diameter	=	4.0	IN	=	339.0 CF	=	2536 Gallon
Total Depth	=	3,885.0	FT				
S-C-B mixture							
weight of mix	=	2,300	LB/CY				
weight of instiu material	=	3,800	LB/CY				
Weight of mix installed	=	850	LB/CY				
Material removed from site	=	22%					
Volume removed from site	=	19,291	BCY	=	24,113.2	LCY	
Site Work							
Silt Fence	=	22,176.0	FT				
Silt Boom	=	22,176.0	FT				
Clearing and Grubbing	=	665,280.0	SF	=	73,920.0	SY	assumed a 30 ft width
Site Restoration	=	73,920.0	SY	=	15.3	ACRE	
Haul Road Maintenance	=	34,496.0	SY				
Berm Size	=	0.25	ECY/LF				
Volume of berm	=	5,544.0	ECY				

Feature of Work:	STRUCTURAL REMOVAL OF FLASH BOARD CULVERT

Scope Given:	Remove flash board culvert S-346 from old Tamiami Trail if approximately 5.5 miles of the L-67 Extension Levee is removed.

Reference for Scope Basis:	Engineering Appendix, March 2013, Table A-1, p. 11

Scope Assumptions:	- Assume road to be removed is 250 feet in length - Assume road is covered with 3 inches of asphalt. - Assume road width is 30 FT. - Assume height of road is 12 ft above bottom of culvert with side slopes of 2:1. - Assume that all material coming from the levee will need processing prior to reuse as backfill. - Assume all asphalt is hauled off site to disposal. - Assume dense vegetation on the side slopes of the road will need to be removed. - Assume culvert length is 100 ft - Assume culvert dimensions from the design documentation of similar structures is correct. - Assume all culvert steel material will be hauled off site -Assume no backfill is needed

Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes

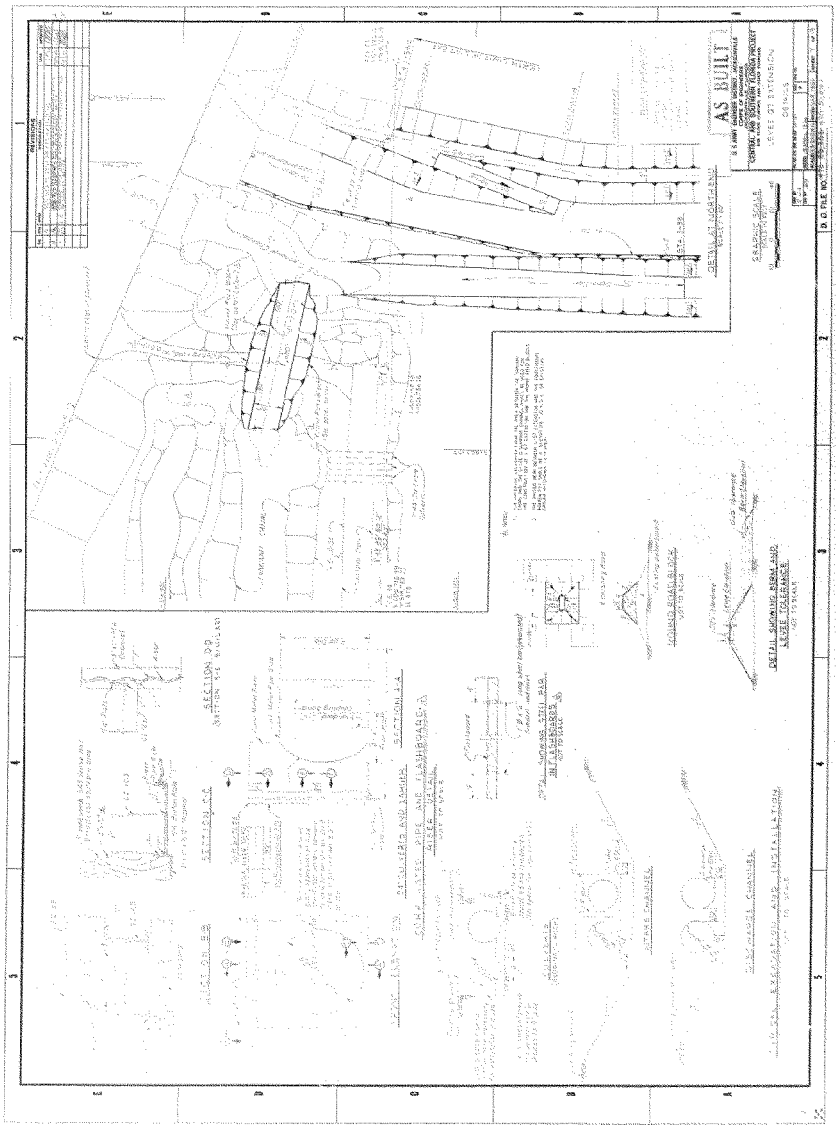
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)

Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.

Sequence of Work:	- Site survey and stake entire area of the road removal. - Silt Fence and floating turbidity boom the entire site. Silt fence and floating turbidity boom maintenance will be ongoing during construction. - Remove asphalt and haul to offsite disposal. - Remove road prism and haul to processing. - Remove existing flashboard culvert and haul to offsite disposal - Remove silt fence and turbidity boom and restore site.

Key Outstanding Questions/Issues:	Appendix mentions a design capacity of 165 CFS. This is the only mention in Table A-1 of a structure being removec having a design capacity. At this time there is not sufficient data to estimate the removal of the structure more information is needed. Drawings of Structure and drawings or condition of site after removal are needed to estima this feature. Information was provided.

Representative Drawings/Photos: Structural Removal of Flashboard Culvert



Feature of Work: STRUCTURAL REMOVAL OF FLASH BOARD CULVERT

Quantity Take Off:

Road Way Removal

Length	=	250.0	FT						
Height	=	12.0	FT						
Slope1	=	2.0	:1						
Slope2	=	2.0	:1						
Top width	=	30.0	FT						
Bottom Width	=	78.0	FT						
Cross Section	=	648.0	SF						
Surface Area of Prism	=	41,041.0	SF	=	0.9	ACRE			
Volume	=	162,000.0	CF	=	6,000.0	BCY	=	7,500.0	LCY
base area of Prism	=	19,500.0	SF	=	2,166.7	SY	=	0.4	Acre
side slopes of Prism	=	33,541.0	SF	=	3,726.8	SY	=	0.8	Acre
roadway area	=	7,500.0	SF	=	833.3	SY	=	0.2	Acre
Asphalt Thickness	=	3.0	IN						
Asphalt Volume	=	1,875.0	CF	=	69.4	BCY			

Structure Demo

CMP

No. of Barrels	=	2.0	EA		
Diameter of Culvert	=	72.0	IN	6.0	FT
Length of Culvert	=	100.0	FT		
Diameter of Riser	=	96.0	IN	8.0	FT
Height of Riser	=	12.0	FT		

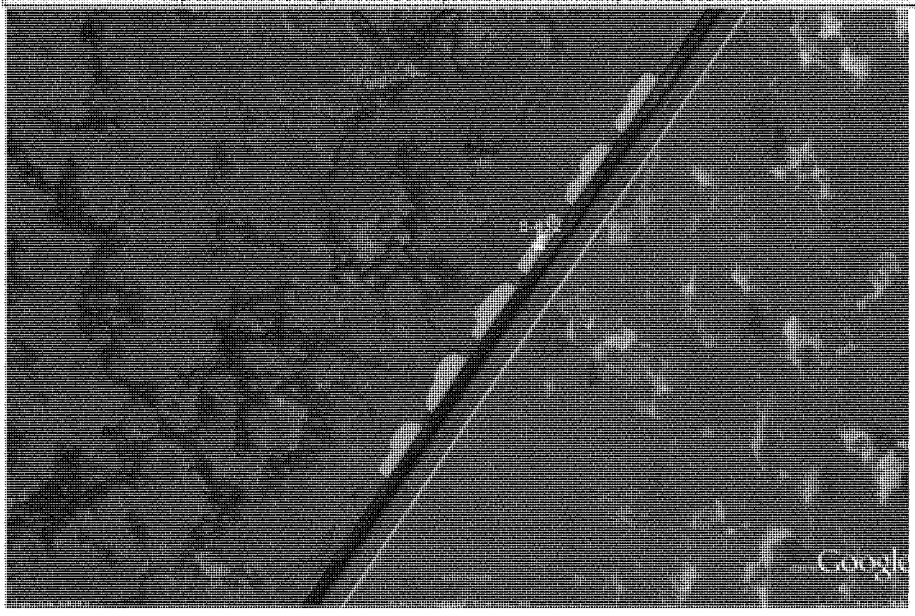
Misc Metal Demo

C3x2x3/16 Weight	=	4.5	LB/FT		
Total length	=	64.0	FT	288.0	LB
I 6x12.5 Weight	=	12.5	LB/FT		
Total length	=	80.0	FT	1000.0	LB
PL 3/16" Weight	=	7.7	LB/FT^2		
Total Area	=	64.0	FT^2	490.2	LB
Total Metal Weight	=	1778.2	LB	0.9	TONS

Feature of Work:	L-67A Spoil Mounds in the Vicinity of S-631, 632 and 633

Scope Given:	Removal of spoil along the western L-67A canal in the vicinity of the new control structures.
Reference for Scope Basis:	Engineering Appendix, March 2013, p. A-8 Line 77.
Scope Assumptions:	- Assume Spoil mound dimensions similar to those along the Miami Canal and average 475 ft long and 130 ft wide measured from Google Earth. Average height above 10.0 ft elevation is 3.5 ft. - Assume top width of L-67A is 110 ft (as measured from Google Earth). - Assume L-67A canal is 20 ft deep. - Assume a flexible float barge and conveyor will transport excavated mound material across canal to the crest of t levee and deposited into a dump truck be transported to a spoil site for later use. - Assume a Dozer and excavator will excavate the spoil mound and load onto the conveyor. - Assume 3 upstream and 3 downstream of the proposed structures will be degraded (18 total). - Assume each spoil mound is 1.5 acres. - Assume silt fence will be required around perimeter of spoil mound and a floating silt boom required up and dow stream of the spoil mound. - Assume all material is levee grade material. - Assume excavated material will be hauled and stored near S-333 for later use or material is deposited along the L 67D levee for immediate use and average haul distance to the spoil mounds is 10 miles
Supporting Documentation: (by Cost Team)	Quantity Takeoff, Material Quotes
Class of Estimate	Class 3 - Baseline (Feasibility/DPR/LRR)
Estimate Methodology:	When possible a corollary approach to the estimate development was utilized. Plans and specifications for recent similar work were utilized to capture the necessary scope and assumptions to construct the feature. The scope anc assumptions were documented and sent to the design team for review. After reaching consensus on the scope anc major assumptions, the labor, equipment, materials, and production rates were developed for the estimate.
Sequence of Work:	- Site survey and stake entire area of the road removal. - Silt Fence and floating turbidity boom the entire site. Silt fence and floating turbidity boom maintenance will be ongoing during construction. - Install and anchor floating plant and conveyor. - Excavate material and deposited it on the east side of the levee for a truck turnaround. -Excavate and haul material to S-333 area for use on L-67D levee.
Key Outstanding Questions/Issues:	

Representative Drawings/Photos: I-67A Spoil Mounds in the Vicinity of S-631, 632 and 633



Feature of Work: L-67A Spoil Mounds in the Vicinity of S-631, 632 and 633

Quantity Take Off:

Spoil Mounds

Length	=	475.0	LF			
Width	=	130.0	LF			
depth	=	3.5	LF			
Perimeter	=	1,210.0				
Surface Area	=	61,750.0	SF			
Volume	=	216,125.0	CF	=	8,005	BCY

Total volume for all 18 spoil mounds = 144,090.0 BCY

Haul Road Maintenance

Assume 15 ft wide and 10 miles long

88,000.0 SY

Cut Fill Study

	Excavation									
	organic		common		Cap Rock Material		Inter-bedded Material		Levee Excavation	
Structure	BCY	LCY	BCY	LCY	BCY	LCY	BCY	LCY	BCY	LCY
S-333	10,022.2	12,527.8	-	-	52,970.4	79,455.6	40,443.3	60,665.0	8,848.9	11,061.1
S-356	39,802.3	49,752.8	-	-	17,219.0	25,828.5	-	-	11,150.9	13,938.6
S-631	4,744.4	5,930.6	-	-	10,697.3	16,046.0	-	-	3,811.1	4,763.9
S-632	4,744.4	5,930.6	-	-	10,697.3	16,046.0	-	-	3,811.1	4,763.9
S-633	4,744.4	5,930.6	-	-	10,697.3	16,046.0	-	-	3,811.1	4,763.9
L-67C Gap	8,138.4	10,173.0	-	-	-	-	-	-	19,639.4	24,549.2
L-67D	977,386.7	1,221,733.3	-	-	-	-	-	-	11,635.6	14,544.4
L-67C	57,294.3	71,617.9	-	-	-	-	-	-	138,261.3	172,826.6
S-355W	-	-	-	-	3,318.5	4,977.8	4,000.0	6,000.0	-	-
L-29	30,795.7	38,494.6	-	-	-	-	-	-	305,559.9	381,949.8
Remove TT	-	-	-	-	-	-	-	-	234,666.7	293,333.3
L-67Ext	-	-	-	-	-	-	-	-	292,551.1	365,688.9
L-31N	-	-	-	-	-	-	-	-	86,240.0	107,800.0
S-346	-	-	-	-	-	-	-	-	6,000.0	7,500.0
L-67A Spoils									144,090.0	180,112.5
TOTAL	1,137,672.9	1,422,091.1	-	-	105,599.9	158,399.9	44,443.3	66,665.0	1,270,076.9	1,587,596.2

	Fill	
	Levee Quality Material	
Structure	ECY	LCY
S-333	6,577.8	7,432.9
S-356	37,436.9	42,303.7
S-631	10,511.1	11,877.6
S-632	10,511.1	11,877.6
S-633	10,511.1	11,877.6
L-67C Gap	-	-
L-67D	1,296,533.3	1,465,082.7
L-67C	-	-
S-355W	4,000.0	4,520.0
L-29	-	-
Remove TT	-	-
L-67Ext	292,551.1	330,582.8
L-31N	-	-
S-346	-	-
L-67A Spoils	-	-
TOTAL	1,668,632.5	1,885,554.7

Processed LCY	=	1,812,661.0	LCY
Needed LCY	=	1,885,554.7	LCY
rejected/unused processed	=	(72,893.6)	LCY
Needs Removed From Site	=	-4.02%	

Due to construction Sequence L-29 Levee will degraded after all other features are in place.

Processed LCY	=	1,430,711.2	LCY
Needed LCY	=	1,885,554.7	LCY
rejected/unused processed	=	(454,843.5)	LCY
Needs Removed From Site	=	-31.79%	

APPENDIX C
ENVIRONMENTAL AND CULTURAL RESOURCES

Appendix C.1 Existing and Future Without Project Conditions

Appendix C.2.1 Effects of the Alternatives

Appendix C.2.2 Effects of the Recommended Plan

Appendix C.3 Pertinent Correspondence Information

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APPENDIX C.1

EXISTING AND FUTURE WITHOUT PROJECT CONDITIONS

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C.1 EXISTING AND FUTURE WITHOUT PROJECT CONDITIONS

C.1.1 EXISTING CONDITIONS OF RESOURCES

The study area for the Central Everglades Planning Project (CEPP) encompasses the Northern Estuaries (St. Lucie River and Indian River Lagoon and the Caloosahatchee River and Estuary), Lake Okeechobee, a portion of the Everglades Agricultural Area (EAA), the Water Conservation Areas (WCAs), Everglades National Park (ENP), the Southern Estuaries (Florida Bay and Biscayne Bay), and the Lower East Coast (LEC). The following describes the existing physical, ecological, and socioeconomic conditions within this large study area. The existing conditions are presented in a regional or area specific content depending on the nature of the resource or the anticipated effect of that resource. Existing conditions are summarized in **Section 2.0** of the main report.

C.1.1.1 Vegetative Communities

C.1.1.1.1 Lake Okeechobee

The vegetation and cover types within the Lake Okeechobee region have been greatly altered during the last century. Historically, the natural vegetation was a mix of freshwater marshes, hardwood swamps, cypress swamps, pond apple forests, and pine flatwoods. The freshwater marshes were the predominant cover type throughout, especially along the southern portion of Lake Okeechobee where it flowed into the Everglades. These marshes were vegetated primarily with sawgrass (*Cladium jamaicense*) and scattered clumps of Carolina willow (*Salix caroliniana*), sweetbay (*Magnolia virginiana*) and cypress (*Taxodium* spp.). Hardwood swamps dominated by red maple (*Acer rubrum*), sweetbay, and sweet gum (*Liquidambar styraciflua*) occurred in riverine areas feeding Lake Okeechobee, while cypress swamps were found in depressional areas throughout the region. Pine flatwoods composed of slash pine (*Pinus elliottii*), cabbage palm (*Sabal palmetto*) and saw palmetto (*Serenoa repens*) were prevalent in upland areas, especially to the north.

The majority of the surface of Lake Okeechobee is not vegetated and provides open water (pelagic) habitat. Open water habitat within Lake Okeechobee covers about 75 % of the lake's surface area.

Lake Okeechobee currently has an extensive littoral zone that occupies approximately 150 square miles (about 25 percent) of the lake's surface (Milleson 1987). Littoral vegetation occurs along much of Lake Okeechobee's perimeter, but is most extensive along the southern and western borders (Milleson 1987). The littoral zone plant community is composed of a mosaic of emergent, submergent and native plant species. Emergent vegetation within the littoral zone is dominated by herbaceous species such as cattail (*Typha* spp.), spike rush (*Eleocharis cellulosa*), and the invasive exotic torpedo grass (*Panicum repens*). Other emergent vegetation includes bulrush (*Scirpus californicus*), sawgrass, pickerelweed (*Pontedaria cordata*), duck potato (*Sagittaria* spp.), beakrush (*Rhynochospora tracyi*), wild rice (*Zizania aquatic*), arrowhead (*Sagittaria latifolia*), buttonbush (*Cephalanthus occidentalis*), sand cordgrass (*Spartina bakeri*), fuirena (*Fuirena scirpoidea*), rush (*Scirpus cubensis*), southern cutgrass (*Leersia hexandra*), maidencane (*Panicum hemitomon*), white vine (*Sarcostemma clausum*), dogfennel (*Eupatorium capillifolium*), and mikania (*Mikania scandens*). Woody vegetation consists of primrose willow (*Ludwigia peruviana*), Carolina willow, and the invasive exotic melaleuca (*Melaleuca quiquenervia*). Over the years, there has been an on-going effort to eradicate melaleuca in the Lake Okeechobee region. The eradication effort has been extremely effective.

Submerged vegetation within Lake Okeechobee is composed almost entirely of hydrilla (*Hydrilla verticillata*), an invasive exotic species, pondweed (*Potoamogeton illinoensis*), bladderwort (*Utricularia foliosa*), Chara (*Chara* spp.) and tape grass (*Vallisneria americana*).

The floating, component of the littoral zone consists of lotus lily (*Nelumbo lutea*), fragrant water lily (*Nymphaea odorate* and *N. mexicana*), the invasive exotic water hyacinth (*Eichhornia crassipes*), water lettuce (*Pistia stratiotes*), duckweed (*Lemna* spp.), coinwort (*Hydrocotyle umbellate*), and ludwigia (*Ludwigia leptocarpa*).

C.1.1.1.2 Northern Estuaries

Submerged aquatic vegetation (SAV), which collectively includes seagrass and macroalgae, is one of the most important vegetation communities of the St. Lucie River, Indian River Lagoon, and the Caloosahatchee River and Estuary (IRL CCMP 1996). These communities are highly productive and provide food for fish, sea turtles, manatees, a myriad of invertebrates, and other species. Seagrass meadows improve water quality by removing nutrients, dissipating the effects of waves and currents, and by stabilizing bottom habitats thereby reducing suspended solids. Seagrass beds support some of the most abundant and diverse fish populations in the Indian River Lagoon. Many commercial and recreational fisheries (e.g. clams, shrimp, lobster, and fish) are associated with healthy seagrass beds (US Fish and Wildlife Service (USFWS 1999). Currently, many SAV beds are stressed and have been reduced or eliminated from their former areas by extreme salinity fluctuations, increased turbidity, sedimentation, dredging, damage from boats, and nutrient enrichment which causes algal blooms that, in turn, restrict light penetration.

C.1.1.1.2.1 Upper Caloosahatchee River and Estuary

In terms of distribution and abundance tape grass has been the dominant species in the upper Caloosahatchee River and Estuary, colonizing littoral zones in water of less than one meter (Chamberlain and Doering 1998a). In the early 1990s, tape grass covered approximately 1,000 acres and about 60% of the coverage occurred within an 8-kilometer (km) stretch between Beautiful Island and the Fort Myers Bridge (Hoffacker 1994). Total longitudinal cover ranged from 14 to 32 km upstream from Shell Point (Chamberlain and Doering 1998b). Tape grass can typically tolerate salinities of 3 to 5 practical salinity units (psu) with few long-term effects if light conditions are sufficient (Haller et al. 1974, French and Moore 2003, Jarvis and Moore 2008). Dramatic declines in tape grass were observed beginning in late 2006 as a result of salinities exceeding the species' tolerance (Bourn 1932, Haller et al. 1974, Doering et al. 1999, Kraemer et al. 1999, Doering et al. 2001). During this period, widgeon grass, (*Ruppia maritime*) was the dominant species although it never achieved even the minimum abundance recorded for tape grass (Burns et al. 2007).

The effects of hurricane water releases in 2005 resulted in decreased plant cover and density in the latter half of 2005. Compounding the high turbidity effects from freshwater releases in 2005, drought conditions caused precipitous increases in salinities beginning in October 2006 raising salinity levels to 10 to 25 psu from November 2006 through April 2008. During the December 2005 to April 2006 period, lower water clarity due to high turbidity was associated with lower shoot density and cover. The loss of plants was quite rapid with a significant end-of-year dieback in 2006 followed by no regrowth in spring 2007. Salinities finally declined between April and October 2008, but tape grass recovery has been slow. This may be related to a lack of propagules as nearly all the tape grass was lost during the late 2006 to 2008 high salinity period. It may also be related to herbivory or other impacts on the initial recolonization of recruits into the area as leaves were sometimes noted as missing their tips (RECOVER 2009).

C.1.1.1.2.2 Lower Caloosahatchee River Estuary

Historically, two species of SAV have been routinely reported during surveys in the lower Caloosahatchee River Estuary upstream of Shell Point. These include shoal weed *(Halodule beuadettei)* or shoal grass (*H. wrightii*) and turtle grass (*Thalassia testudinum*) (Chamberlain and Doering 1998a, Wilzbach et al. 2000, Burns et al. 2007). In more recent reports, manatee grass (*Syringodium filiforme*) has been reported in San Carlos and Tarpon Bays (Wilzbach et al. 2000, Burns et al. 2007). Shoal grass coverage, described as abundant, has been at 300 acres; about 75% of this occurred between two and eight kilometers (km) upstream of Shell Point (Chamberlain and Doering 1998b).

From 2004 to 2008, the lower estuary was dominated by shoal grass. Although widgeon grass was observed occasionally (Burns et al. 2007); only very low densities of widgeon grass were found in the lower estuary when surveys were searching specifically for it. High salinity fluctuations with tides and shading by shoal grass may limit its growth. Low salinities during higher rainfall periods and discharge events observed since 2004 likely prevented the survival of seagrass species such as turtle grass (Burns et al. 2007). Water clarity was poor in 2004 and 2005 preventing SAV growth in waters greater than 0.7 meter deep. Water clarity conditions improved in 2007 and were sufficient for growth down to 1.2 meters.

Hurricane effects lowering SAV abundance in 2005 and 2006 and subsequent shoal grass recovery in 2007 are evident with cover in 2007 exceeding 2004 levels. Salinities of one psu or less occurred each year from 2004 to 2006 due to high rainfall within the watershed.

C.1.1.1.2.3 St. Lucie Estuary

The St. Lucie Estuary and Southern Indian River Lagoon support six species of seagrass including shoal grass, manatee grass, turtle grass, paddle grass, star grass *(Halophila engelmannii)*, and the threatened Johnson's seagrass (*Halophila johnsonii*). Johnson's seagrass was listed as threatened under the Endangered Species Act (ESA) in 1998, and critical habitat was designated in 2000. The species has a very limited distribution along the east coast of Florida from central Biscayne Bay to Sebastian Inlet. Major threats include propeller scarring, dredging, sedimentation, and degraded water quality. Shoal grass and manatee grass are the dominant canopy species in the lagoon (Thompson 1978, Dawes et al. 1995, Morris et al. 2000). While all of these species are most successful in salinities greater than 20 psu, shoal grass can tolerate a wide range of salinity and salinity variations. However, manatee grass is not as tolerant of low salinities or widely varying salinities (Irlandi 2006).

The SAV distribution has been mapped in the St. Lucie Estuary and the Southern Indian River Lagoon every two to three years since 1986, including annual mapping from 2005 through 2007 to help assess hurricane impacts. Historic SAV maps show SAV extending throughout the estuary. In 2007, very sparse (< 10% cover in most areas) SAV was present in the lower and middle estuary. Three seagrass species occurred within the estuary: shoal grass, Johnson's seagrass, and paddle grass. The majority of the SAV occurred in small isolated patches. The dominant SAV species in 2007 was Johnson's seagrass. It also extended farther upstream than any other SAV species.

This region was impacted by hurricanes and associated freshwater discharges in 2004 and 2005. Following the hurricanes, observed impacts to southern Indian River Lagoon SAV communities included large coverage and density declines and smaller direct impacts due to burial by shifting bottom sediments. Lush manatee grass beds were documented through 2004, however, low

salinities and associated poor water quality following the 2004 and 2005 hurricanes greatly impacted manatee grass in the area. The hurricanes also altered bathymetry on the east and west edges of the estuary, covering seagrasses. The steepest decline in percent occurrence of manatee grass occurred in 2005 after Hurricane Wilma. Johnson's seagrass followed by shoal grass colonized the former manatee grass habitat and recruited throughout the site. Available data indicates a clear trend toward recovery of the manatee grass beds.

C.1.1.1.3 Everglades Agricultural Area

Currently, much of the native south Florida landscape has been destroyed or substantially reduced by development, hydrologic change, increased nutrients, and the invasion of exotic plants. South of Lake Okeechobee, the historic pond apple swamps and sawgrass marshes have been converted to agriculture. Habitat types within the EAA are divided into five general groups: aquatic, wetland, upland, disturbed (mostly agricultural), and urban/extractive.

The aquatic communities within the EAA include both natural and man-made areas of open water such as canals, ditches, and ponds. The primary canals include Bolles, Cross, Hillsboro, Miami, North New River, and West Palm Beach Canals. The storage and treatment management measures for CEPP south of Lake Okeechobee are recommended to be located on and maximize the usage of the previously purchased A-1 and A-2 Compartments of the EAA land south of Lake Okeechobee that are owned by the State of Florida (See **Section 3.0**). All of Compartment A of the Talisman Land Exchange property is considered to be atypical jurisdictional wetlands based on hydric soils and hydrology. Wetland vegetation is anticipated to return to the site should agricultural practices cease. Upland land cover classes include dry prairie, hardwood hammock and forests, pinelands, and mixed hardwood pine forests. Disturbed communities consist of mostly agricultural lands including pasture (improved and unimproved), row crops, sugarcane, citrus, and other agricultural lands. Most of the urban and extractive lands are concentrated around the Belle Glade area. Low impact urban areas consist of either vegetated or non-vegetated lands within areas such as lawns, golf courses, road shoulders, and grassy areas surrounding development. High impact urban areas are non vegetated sites such as buildings, roads, and parking lots. Extractive cover areas consist of surface mining operations such as limestone quarries, phosphate mines, and sand pits as well as the associated industrial complexes.

C.1.1.1.4 Greater Everglades

The Everglades landscape is dominated by a complex of freshwater wetland communities that includes open water sloughs and marshes, dense grass and sedge dominated marshes, forested islands, and wet marl prairies. The primary factors influencing the distribution of dominant freshwater wetland plant species of the Everglades are soil type, soil depth, and hydrological regime (USFWS 1999). These communities generally occur along a hydrological gradient with the slough/open water marsh communities occupying the wettest areas (flooded more than nine months per year), followed by sawgrass marshes (flooded six to nine months per year), and wet marl prairie communities (flooded less than six months per year) (USFWS 1999). The Everglades freshwater wetlands eventually grade into intertidal mangrove wetlands and sub tidal seagrass beds in the estuarine waters of Florida Bay.

Development and drainage over the last century have dramatically reduced the overall spatial extent of freshwater wetlands within the Everglades, with approximately half of the predrainage 2.96 million acres of wetlands being converted for development and agriculture (Davis and Ogden 1997). Alteration of the normal flow of freshwater through the Everglades has also contributed to

conversions between community types, invasion by exotic species, and a general loss of community diversity and heterogeneity.

Many areas of WCA 3A still contain relatively good wetland habitat consisting of a complex of tree islands, sawgrass marshes, wet prairies, and aquatic sloughs. Water lilies (*Nymphaea alba*) were originally widespread in sloughs throughout many areas of WCA 3A (McVoy et. al. 2011). Reduced freshwater inflow and drainage by the Miami Canal have overdrained the northern portion of WCA 3A, resulting in increased fire frequency and the associated loss of tree islands, wet prairie, and aquatic slough habitat. Northern WCA 3A is currently dominated largely by mono-specific sawgrass stands with large areas of shrubs and monotypic cattail. Northern WCA 3A lacks the diversity of communities that exists in southern WCA 3A. In southern WCA 3A, Woods and Tanner (1990) documented the trend toward deep water lily dominated sloughs due to impoundment. In approximately 1991, the hydrology of southern WCA 3A shifted to the deeper water and extended hydroperiods of the new, wet hydrologic era resulting in a northward shift in slough vegetation communities within the WCA 3A impoundment (Zweig and Kitchens 2008). Typical Everglades vegetation, including tree islands, wet prairies, sawgrass marshes, and aquatic sloughs also occur throughout WCA 3B. However, within WCA 3B, the ridge and slough landscape has been severely degraded by the virtual elimination of overland sheetflow due to the L-67 canal and levee system. WCA 3B experiences very little overland flow and has become primarily a rain-fed system predominated by shorter hydroperiod sawgrass marshes with relatively few sloughs or tree islands remaining. Water levels in WCA 3B are also too low and do not vary seasonally, contributing to poor ridge and slough patterning. Loss of sheetflow to WCA 3B has also accelerated soil loss reducing elevations of the remaining tree islands in WCA 3B and making them vulnerable to high water stages.

Vegetative trends in ENP have included a substantial shift from the longer hydroperiod slough/open water marsh communities to shorter hydroperiod sawgrass marshes (Davis and Ogden 1997, Armentano et al. 2006). Flows through Shark River Slough (SRS) under current system compartmentalization and water management practices are greatly reduced when compared with pre-drainage conditions. The result has been lower wet season depths and more frequent and severe dry downs in sloughs and reduction in extent of shallow water edges (McVoy et.al. 2011). Over-drainage in the peripheral wetlands along the eastern flank of Northeast Shark River Slough (NESRS) has resulted in shifts in community composition, invasion by exotic woody species and increased susceptibility to fire. Areas within the eastern marl prairies along the boundary of ENP suffer from over-drainage, reduced water flow, exotic tree invasion and frequent human-induced fires (Lockwood et al. 2003; Ross et al. 2006). In addition, invasion of sawgrass marshes and wet prairies by exotic woody species has led to the conversion of some marsh communities to forested wetlands (Gunderson et al. 1997).

The estuarine communities of Florida Bay have also been affected by upstream changes in freshwater flows through the Everglades. A reduction in freshwater inflows into Florida Bay and alterations of the normal salinity balance have affected mangrove community composition and may have contributed to a large-scale die-off of seagrass beds (USFWS 1999).

In contrast to the vast extent of wetland communities, upland communities comprise a relatively small component of the Everglades landscape and are largely restricted to Long Pine Key, the northern shores of Florida Bay, and the many tree islands scattered throughout the region. Vegetative communities of Long Pine Key include rockland pine forest and tropical hardwood forest.

In addition, substantial areas of tropical hardwood hammock occur along the northern shores of Florida Bay and on elevated portions of some forested islands.

C.1.1.1.4.1 Slough/Open Water Marsh

The slough/open water marsh community occurs in the lowest, wettest areas of the Everglades. This community is a complex of open water marshes containing emergent, floating aquatic, and submerged aquatic vegetation components. The emergent marsh vegetation is typically dominated by spikerushes (*Eleocharis cellulosa* and *E. elongata*), beakrushes, and maidencane. Common floating aquatic dominants include fragrant water lily, floating hearts (*Nymphoides aquatica*), and spatterdock (*Nuphar lutea*); and the submerged aquatic community is typically dominated by bladderwort (*Utricularia foliosa*) and periphyton. As shown by Davis et al. (1994), vegetative trends in ENP have included the conversion of slough/open-water marsh communities to shorter hydroperiod sawgrass marshes.

C.1.1.1.4.2 Sawgrass Marsh

Sawgrass marshes are dominated by dense to sparse stands of *Cladium jamaicense*. Sawgrass marshes occurring on deep organic soils (more than one meter) form tall, dense, nearly monospecific stands. Sawgrass marshes occurring on shallow organic soils (less than one meter) form sparse, short stands that contain additional herbaceous species such as spikerush, water hyssop (*Bacopa caroliniana*), and marsh mermaid weed (*Proserpinaca palustris*) (Gunderson et al. 1997). The adaptations of sawgrass to flooding, burning, and oligotrophic conditions contribute to its dominance of the Everglades vegetation. Sawgrass-dominated marshes once covered an estimated 300,000 acres of the Everglades. Approximately 70,000 acres of tall, monospecific sawgrass marshes have been converted to agriculture in the EAA. Urban encroachment from the east and development within other portions of the Everglades has consumed an additional 79,000 acres of sawgrass-dominated communities (Davis and Ogden 1997).

C.1.1.1.4.3 Wet Marl Prairies

Wet marl prairies occur on marl soils and exposed limestone and experience the shortest hydroperiods of the slough/marsh/prairie wetland complex. Marl prairie is a sparsely vegetated community that is typically dominated by muhly grass (*Muhlenbergia capillaris*) and short-stature sawgrass. Additional important constituents include black sedge (*Schoenus nigricans*), arrowfeather (*Aristida purpurascens*), Florida little bluestem (*Schizachyrium rhizomatum*), and Elliot's lovegrass (*Eragrostis elliottii*). Periphyton mats that grow loosely attached to the vegetation and exposed limestone also form an important component of this community. Marl prairies occur in the southern Everglades along the eastern and western periphery of SRS. Approximately 146,000 acres of the eastern marl prairie have been lost to urban and agricultural encroachment (Davis and Ogden 1997). Pollen data indicate that the marl prairies west of SRS are not a natural feature of the Everglades landscape but developed after twentieth century hydrologic modification of the system reduced flow to the region (Bernhardt and Willard 2006). Prior to the modifications, plant communities at the sites analyzed by Bernhardt and Willard (2006) in western SRS consisted of sawgrass marshes. Based on their analysis of pollen records, the authors concluded that "the current spatial distribution and community composition of marl prairies are a response to water management and land cover changes of the twentieth century; and further sampling of modern marl prairie communities and adjacent communities is necessary to document the pre- and post-drainage distribution of marl prairie" (Bernhardt and Willard 2006).

C.1.1.1.4.4 Tree Islands

Tree islands occur within the freshwater marshes in areas of slightly higher elevation relative to the surrounding marsh. The lower portions of tree islands are dominated by hydrophytic, evergreen, broad-leaved hardwoods such as red bay (*Persea palustris*), sweetbay, dahoon holly (*Ilex cassine*), and pond apple (*Annona glabra*). Tree islands typically have a dense shrub layer that is dominated by coco-plum (*Chrysobalanus icaco*). Additional constituents of the shrub layer commonly include buttonbush and large leather fern (*Acrostichum danaeifolium*). Elevated areas on the upstream side of some tree islands may contain an upland tropical hardwood hammock community dominated by species of West Indian origin (Gunderson et al. 1997), with species composition shifting toward the north toward more temperate hardwood hammock species. Extended periods of flooding may result in tree mortality and conversion to a non-forested community. In the over-drained areas of WCA 3A, historic wildfires have consumed tree island vegetation and soils. Overall, the spatial extent of tree islands in WCA 3 declined by 61% between 1940 and 1995 (Patterson and Finck 1999). Portions of the WCAs have been flooded to the extent that many forested islands have lost all tropical hardwood hammock trees. Tree islands are considered an extremely important contributor to habitat heterogeneity and overall species diversity within the Everglades ecosystem because they provide nesting habitat and refugia for birds and upland species and serve as hotspots of plant species diversity within the Greater Everglades (Sklar and van der Valk 2002, USFWS 1999). Tree islands also contain extraordinarily high levels of total phosphorpus (TP) in their soil suggesting that they may play a major role in the biogeochemical cycles of nutrients in the Everglades (Trexler and Childers 2010, Wetzel et al. 2009, 2011). Wetzel et al. (2011) found that soil TP levels within WCA 3A and WCA 3B tree islands were approximately 4 times higher than the surrounding marsh TP levels. Tree islands within WCA 3B may help to capture and focus nutrients, assisting to minimize potential effects on sawgrass and wet prairie communities within this region (Wetzel et al. 2011).

C.1.1.1.4.5 Mangroves

Mangrove communities are forested wetlands occurring in intertidal, low-wave-energy, estuarine and marine environments. Extensive mangrove communities occur in the intertidal zone of Florida Bay. Mangrove forests have a dense canopy dominated by four species: red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*), and buttonwood (*Conocarpus erectus*). Mangrove communities occur within a range of salinities from 0 to 40 psu. Florida Bay experiences salinities in excess of 40 psu on a seasonal basis. Declines in freshwater flow through the Everglades have altered the salinity balance and species composition of mangrove communities within Florida Bay, favoring more salt tolerant species. Changes in freshwater flow can lead to an invasion by exotic species such as Australian pine (*Casuarina equisetifolia*) and Brazilian pepper (*Schinus terebinthifolius*).

C.1.1.1.4.6 Seagrass Beds

Seagrasses are submerged vascular plants that form dense rooted beds in shallow estuarine and marine environments. This community occurs in sub tidal areas that experience moderate wave energy. Within the action area, extensive seagrass beds occur in Florida Bay. The most abundant seagrasses in south Florida are turtle grass, manatee grass, and shoal grass. Additional species include star grass, paddle grass, and Johnson's seagrass. Widgeon grass may also occur in seagrass beds in areas of low salinity. Seagrasses have an optimum salinity range of 24 to 35 psu, but can tolerate considerable short-term salinity fluctuations. Large-scale seagrass die-off has occurred in Florida Bay since 1987, with over 18 percent of the total bay area affected. Suspected causes of seagrass mortality include high salinities and temperatures during the 1980s and long-term reductions of freshwater inflow to Florida Bay (RECOVER 2009).

C.1.1.1.4.7 Rockland Pine Forest

Pine rocklands within the action area occur on the Miami Rock Ridge and extend into the Everglades as Long Pine Key. Pine rocklands occur on relatively flat terrain with moderate to well-drained soils. Most sites are wet for only short periods following heavy rains (Florida Natural Areas Inventory 1990). Limestone bedrock is close to the surface and the soils are typically shallow accumulations of sand, marl, and organic material. Pine rockland is an open, savannah-like community with a canopy of scattered south Florida slash pine and an open, low-stature understory. This is a fire-maintained community that requires regular burns to maintain the open shrub/herbaceous stratum and to control hardwood encroachment (Gunderson et al. 1997). The overstory is comprised of scattered south Florida slash pines. The shrub layer is comprised of a diverse assemblage of tropical and temperate species. Common shrubs include cabbage palm, coco-plum (*Chrysobalanus icaco*), myrsine (*Rapanea punctata*), saw palmetto, southern sumac (*Rhus copallinum*), strangler fig (*Ficus aurea*), swamp bay (*Persea palustris*), wax myrtle (*Myrica cerifera*), white indigo berry (*Randia aculeata*), and willow-bustic (*Sideroxylon salicifolium*). The herbaceous stratum is comprised of a very diverse assemblage of grasses, sedges, and forbs. Common herbaceous species include crimson bluestem (*Schizachyrium sanguineum*), wire bluestem (*S. gracile*), hairy bluestem (*Andropogon longiberbis*), bushy bluestem (*A. glomeratus* var. *pumilis*), candyweed (*Polygala grandiflora*), creeping morning-glory (*Evolvulus sericeus*), pineland heliotrope (*Heliotropium polyphyllum*), rabbit bells (*Crotolaria rotundifolia*), and thistle (*Cirsium horridulum*) (USFWS 1999b). This community occurs on areas of relatively high elevation and consequently, has been subject to intense development pressure. In addition, fragmentation, fire suppression, invasion by exotic species, and a lowered water table have negatively affected the remaining tracts of pine rockland (USFWS 1999b).

C.1.1.1.4.8 Tropical Hardwood Hammock

Tropical hardwood hammocks occur on upland sites where limestone is near the surface. Tropical hardwood hammocks within the action area occur on the Miami Rock Ridge, along the northern shores of Florida Bay, and on elevated outcrops on the upstream side of tree islands. This community consists of a closed canopy forest dominated by a diverse assemblage of hardwood tree species, a relatively open shrub layer, and a sparse herbaceous stratum. This community is dominated by native south Florida species that represent the northern extension of the ranges of species that occur throughout the West Indies, but nowhere else in the continental United States. Common canopy species include gumbo limbo (*Bursera simaruba*), paradise tree (*Simarouba glauca*), pigeon-plum (*Coccoloba diversifolia*), strangler fig, wild mastic (*Sideroxylon foetidissimum*), willow-bustic, live oak (*Quercus virginiana*), short-leaf fig (*Ficus citrifolia*), and wild tamarind (*Lysiloma bahamense*). Common understory species include black ironwood (*Krugiodendron ferreum*), inkwood (*Exothea paniculata*), lancewood (*Ocotea coriacea*), marlberry (*Ardisia escallonoides*), poisonwood (*Metopium toxiferum*), satinleaf (*Chrysophyllum oliviforme*), and white stopper (*Eugenia axillaris*). Common species of the sparse shrub/herbaceous layer include shiny-leaf wild-coffee (*Psychotria nervosa*), rouge plant (*Rivinal humilis*), false mint (*Dicliptera sexangularis*), bamboo grass (*Lasciacis divaricata*), and woods grass (*Oplismenus hirtellus*). This community occurs on areas of relatively high elevation and consequently, has been subject to intense development pressure. Fragmentation of remaining tracts, invasion by exotic species, and alterations of water table elevations have also had negative impacts on this community. Tropical hardwood hammocks on the Miami Rock Ridge have been affected by a lowered water table associated with the reduction of freshwater flow through the Everglades. In contrast, tree islands in the WCAs have been flooded to the extent that many have lost all tropical hardwood hammock trees.

C.1.1.2 Fish and Wildlife Resources

Aquatic macroinvertebrates form a vital link between the algal and detrital food web base of freshwater wetlands and the fishes, amphibians, reptiles, and wading birds that feed upon them. Important macroinvertebrates of the freshwater aquatic community include crayfish (*Procambarus alleni*), riverine grass shrimp (*Palaemonetes paludosus*), amphipods (*Hyallela aztecus*), Florida apple snail (*Pomacea paludosa*), Seminole ramshorn (*Planorbella duryi*), and numerous species of aquatic insects (USACE 1999).

Small freshwater marsh fishes are also important processors of algae, plankton, macrophytes, and macroinvertebrates. Marsh fishes provide an important food source for wading birds, amphibians, and reptiles. Common small freshwater marsh species include the native and introduced golden topminnow (*Fundulus chrysotus*), least killifish (*Heterandria formosa*), Florida flagfish (*Jordenella floridae*), golden shiner (*Notemigonus crysoleucas*), sailfin molly (*Poecilia latipinna*), bluefin killifish (*Lucania goodei*), oscar (*Astronotus ocellatus*), eastern mosquitofish (*Gambusia holbrookii*), and small sunfishes (*Lepomis* spp.) (USACE 1999). The density and distribution of marsh fish populations fluctuate with seasonal changes in water levels. Populations of marsh fishes increase during extended periods of continuous flooding during the wet season. As marsh surface waters recede during the dry season, marsh fishes become concentrated in areas that hold water through the dry season. Concentrated dry season assemblages of marsh fishes are more susceptible to predation and provide an important food source for wading birds (USACE 1999).

Within the Greater Everglades, numerous sport and larger predatory fishes occur in deeper canals and sloughs. Common species include largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), redear sunfish (*Lepomis microlophus*), black crappie (*Pomoxis nigromaculatus*), Florida gar (*Lepisosteus platyrhincus*), threadfin shad (*Dorosoma petenense*), gizzard shad (*Dorosoma cepedianum*), yellow bullhead (*Ameiurus natilis*), white catfish (*Ameiurus catus*), bowfin (*Amia calva*), and tilapia (*Tilapia* spp.) (USACE 1999). Larger fishes are an important food source for wading birds, alligators, otters, raccoons, and mink.

The freshwater wetland complex supports a diverse assemblage of reptiles and amphibians. Common amphibians include the greater siren (*Siren lacertina*), Everglades dwarf siren (*Pseudobranchus striatus*), two-toed amphiuma (*Amphiuma means*), pig frog (*Rana grylio*), southern leopard frog (*Rana sphenocephala*), Florida cricket frog (*Acris gryllus*), southern chorus frog (*Pseudacris nigrita*), squirrel tree frog (*Hyla squirela*), and green tree frog (*Hyla cinerea*) (USACE 1999). Amphibians represent an important forage base for wading birds, alligators, and larger predatory fishes (USACE 1999).

Common reptiles of freshwater wetlands include the American alligator (*Alligator mississippiensis*), snapping turtle (*Chelydra serpentina*), striped mud turtle (*Kinosternon bauri*), mud turtle (*Kinosternon subrubrum*), cooter (*Chrysemys floridana*), Florida chicken turtle (*Deirochelys reticularia*), Florida softshell turtle (*Trionys ferox*), water snake (*Natrix sipidon*), green water snake (*Natrix cyclopion*), mud snake (*Francia abacura*), and Florida cottonmouth (*Agkistrodon piscivorus*) (USACE 1999).

The alligator was historically most abundant in the peripheral Everglades marshes and freshwater mangrove habitats, but is now most abundant in canals and the deeper slough habitats of the central Everglades. Drainage of peripheral wetlands and increasing salinity in mangrove wetlands as

a result of decreased freshwater flows has limited the occurrence of alligators in these habitats (Mazzotti and Brandt 1994).

The freshwater wetlands of the Everglades are noted for their abundance and diversity of colonial wading birds. Common wading birds include the white ibis (*Eudocimus albus*), glossy ibis (*Plegadus falcenellus*), great egret (*Casmerodius albus*), great blue heron (*Ardea herodius*), little blue heron (*Egretta caerulea*), tricolored heron (*Egretta tricolor*), snowy egret (*Egretta thula*), green-backed heron (*Butorides striatus*), cattle egret (*Bubulcus ibis*), black-crowned night heron (*Nycticorax nycticorax*), yellow-crowned night heron (*Nycticorax violacea*), roseate spoonbill (*Ajaia ajaja*), and wood stork (*Mycteria americana*) (USACE 1999). The number of wading birds nesting in the Everglades has decreased by approximately 90 percent, and the distribution of breeding birds has shifted away from ENP into the WCAs (Bancroft et al. 1994). The WCAs support fewer numbers of breeding pairs with relatively lower reproductive success (USACE 1999). Water management practices and wetland losses are believed to be the primary cause of the declines (Bancroft et al. 1994).

Mammals that are well-adapted to the aquatic and wetland conditions of the freshwater marsh complex include the rice rat (*Oryzomys palustris natator*), round-tailed muskrat (*Neofiber alleni*), and river otter (*Lutra canadensis*). Additional mammals that may utilize freshwater wetlands on a temporary basis include the white-tailed deer (*Odocoileus virginianus*), Florida panther (*Puma concolor coryi*), bobcat (*Lynx rufus*), and raccoon (*Procyon lotor*).

Many of the fish and wildlife resources that inhabit the freshwater aquatic community of the Everglades are also common to Lake Okeechobee, the Northern Estuaries, and the EAA. Native habitat for fish and wildlife does not comprise a significant amount of the EAA as the alteration of the landscape for agricultural uses has resulted in the removal of nearly all historically occurring native vegetation. Although abundant wetland habitat has been replaced by agriculture, the creation of ditches, canals, and the flooding of fallow agricultural fields provides some habitat for fish and wildlife, particularly during the rainy season.

The Northern Estuaries are also home to fish and wildlife species found in estuarine and marine habitats. Sea grasses and other submerged aquatic vegetation within the Northern Estuaries provide important habitat and nursery grounds for several fish species. Many fish species spend part or all of their life in the estuary. Common recreational and commercial fish species include mutton snapper (*Lutjanus analis*), yellowtail snapper (*Ocyurus chrysurus*), lane snapper (*Lutjanus synagris*), yellowtail parrot fish (*Sparisoma rubripinne*), gag grouper (*Mycteroperca microlepis*), pinfish (*Lagodon rhomboids*), tarpon (*Megalops atlanticus*), common snook (*Centropomus undecimalus*), crevalle jack (*Cranx hippos*), spotted sea trout (*Cynoscion nebulosus*), redfish (*Sciaenops ocellatus*), mullet (*Mugil spp.*), and sheepshead (*Archosargus probatocephalus*). In addition to finfish, the estuaries support a variety of shellfish. Blue crabs (*Callinectes sapidus*), stone crabs (*Menippe mercenaria*), hard clams (*Mercenaria mercenaria*), and oysters (*Crassostrea virginica*) are important estuarine commercial species. Submerged aquatic vegetation and algal communities are also common foraging areas for the green sea turtle (*Chelonia mydas*). The Northern Estuaries provides forage for sea birds (gulls, terns, pelicans, and others), in addition to a large number of wading birds. The Northern Estuaries are also home to marine mammals such as the Atlantic bottlenose dolphin (*Tursiops truncatus*).

C.1.1.3 Invasive and Exotic Species

Executive Order (E.O.) 13112, entitled *Invasive Species*, states an "invasive species means an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health." Alien species (exotic) means, with respect to a particular ecosystem, any species, including its seeds, eggs, spores or other biological material capable of propagating that species and is not native to that ecosystem. Invasive species are broadly defined and can be a plant, animal, fungus, plant disease, livestock disease or other organism. A native species is defined as a species that historically occurred or currently occurs in a particular ecosystem and is not the result of an introduction.

Significant scientific evidence and research document that invasive non-native plants are degrading and damaging south Florida natural ecosystems (Doren and Ferriter 2001). Many species are causing significant ecological impacts by crowding out and displacing native plants, altering soil types and soil/water chemistry, altering ecosystem functions such as carbon sequestration, nutrient cycling and fire regimes, and reducing gene pools and genetic diversity. Non-native invasive animal distribution, extent and impacts are not well understood, however implications of invasive animals are apparent in south Florida. In addition to environmental impacts, invasive species impact human health, reduce agricultural production and property values, degrade aesthetic quality, decrease recreational opportunities and threaten the integrity of human infrastructure such as waterways/navigation channels, locks, levees, dams and water control structures.

Florida is particularly vulnerable to the introduction, invasion and naturalization of non-native species. This is due to several factors including a subtropical climate, dense human population centers, major ports of entry and the pet, aquarium and ornamental plant industries. Major disturbance to the landscape has also increased Florida's vulnerability to invasive species. Alteration of the landscape for urban development, flood control and agricultural uses has exacerbated non-native plant and animal invasions. On average, 10 new organisms per year are introduced into Florida that are capable of establishing and becoming invasive and causing environmental harm. Approximately 90% of the plants and animals that enter the continental United States enter through the port of Miami (Cuda 2009). Stein, Kutner & Adams (2000) estimated that over 32,000 exotic species (25,000 plants and 7,000 animals) have been introduced into Florida. There are approximately 4,000-5000 native species of plants and animals in Florida. The number of non-native species that have been introduced is eight times the total number of native species in the entire state. The Atlas of Florida Vascular Plants (Wunderlin and Hansen 2008) documented 4,289 plant species in Florida. Of the 4,289 plant species, 1,419 were considered non-native and were naturalized (freely reproducing) populations. The Florida Exotic Pest Plant Council (FLEPPC) identifies 76 of the 1,419 species of non-native plants as Category I species in the 2011 Invasive Plant List. Searches through existing data and resources indicate 156 non-native plant species have been documented to occur within the project area. Other non-native species are probably present; however, documented citations could not be located. Of the 156 species of plants documented to occur within the project area, there are 76 FLEPPC Category I species, 38 FLEPPC Category II species, and 28 Florida Noxious Weed species.

According to the 2013 South Florida Environmental Report, there are four species of non-native invasive plants infesting more than 144,770 acres within the Everglades Protection Area (EPA). These species include Australian pine (*Casuarina equisetifolia*), Old World climbing fern (*Lygodium microphyllum*), melaleuca, and Brazilian pepper (*Schinus terebinthifolius*). The acreage of these plants was estimated by the South Florida Water Management District (SFWMD) and the National

Park Service (NPS) through regional invasive plant surveys utilizing digital aerial sketch mapping (DASM). There were 224 surveys completed within the EPA, which is approximately 2.8 million acres in size, between March 2010 and February 2012. Management areas surveyed included Holeyland, Rotenberger and Southern Glades. Other areas surveyed included Seminole Tribe of Florida's Big Cypress Reservation, Loxahatchee National Wildlife Refuge (LNWR), Everglades Wildlife Management Area (WCAs 2 and 3), the Miccosukee Tribe of Indian's Alligator Alley Reservation, Big Cypress National Preserve (BCNP), ENP, East Coast Buffer Lands, South Dade Wetlands and several other areas (SFER 2013). Other non-native plant species of concern within the project area include torpedo grass, tropical American water grass (*Luziola subintegra*), roundleaf toothcup (*Rotala rotundifolia*), and cogon grass (*Imperata cylindrical*).

A primary native nuisance species within the project area is cattail. Many areas within the project area have been invaded by cattails. This is attributed to water with increased phosphorus being delivered to these areas beginning in the late 1950s. Areas where water control structures, conveyance features, and levees exist provide a suitable habitat for invasion and expansion of cattail. Examples of areas that have been impacted include WCA 2, WCA 3A, and ENP canal and levee banks.

Searches through existing data and resources indicate 89 non-native animal species have been documented to occur within the project area. Other non-native animal species are probably present however documented citations could not be located. Information regarding species presence and distribution is largely incomplete for most taxonomic groups of animals. Not all of the 89 non-native animal species identified and documented to occur in the CEPP area will have a significant impact on the ecosystem.

Key species of carnivorous reptiles, such as the Argentine black and white tegu (*Tupinambis merianae*), the Burmese python *(Python molurus bivittatus*) and Nile monitor *(Varanus niloticus*) are currently present within the project area and have potential to cause significant impacts to the ecosystem. These species are among south Florida's most threatening invasive animals and are considered top predators and increase pressures on native wildlife populations, particularly threatened and endangered species (SFER 2013). Other species of concern include the island apple snail (*Pomacea insularum*), purple swamphen (*Porphyrio porphyrio*), Asian swamp eel (*Monopterus albus*), monk parakeet (*Myiopsitta monachus*), feral pig (*Sus scrofa*), and redbay ambrosia beetle (*Xyleborus glabratus*) and associated fungus (*Raffaelea lauricola*). The redbay ambrosia beetle and fungus are of special concern since they are killing bay species on tree islands in ENP and the WCAs.

C.1.1.4 Threatened and Endangered Species

C.1.1.4.1 Federally Protected Species

USACE has coordinated the existence of federally listed species with the United States Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS), as appropriate. Federally listed threatened and endangered species are either known to exist or potentially exist within the project area and, subsequently, may be affected by the proposed project. Many of these species have been previously affected by habitat impacts resulting from wetland drainage, alteration of hydroperiods, wildfire, and water quality degradation. A number of candidate animal and plant species are also known to exist or potentially exist within the project area. For a complete list of federally threatened and endangered species, their critical habitat, and candidate species refer to

the Biological Assessment (BA) included in **Annex A**. The BA also includes descriptions for each species.

C.1.1.4.2 State Listed Species

The study area also provides habitat for several state listed species. For a complete list of state listed species and a description for each species refer to the BA (**Annex A**).

C.1.1.5 Essential Fish Habitat

Essential Fish Habitat (EFH) located within the area affected by CEPP occurs within both the Northern Estuaries (St. Lucie River and Indian River Lagoon and the Caloosahatchee River and Estuary) and the Southern Estuaries (Biscayne Bay and Florida Bay) (National Marine Fisheries Service [NMFS] 2000).

C.1.1.5.1 St. Lucie River and Indian River Lagoon

This portion of the study area is within the jurisdiction of the South Atlantic Fishery Management Council (SAFMC) and is located in areas designated as EFH for wormrock, live bottom habitat, for the American oyster, pink shrimp (*Penaeus duorarum*), white shrimp (*Penaeus* sp.), brown shrimp (*Penaeus aztecus*), redfish , grouper (*Epinephelus* spp.), gray snapper (*Lutjanus griseus*), white grunt (*Haemulon plumieri*), red porgy (*Pagrus pagrus*), spiny lobster (*Panulirus argus*), and the snapper-grouper complex. In addition, the nearshore hardbottom habitat outside of the St. Lucie Estuary is designated as Essential Fish Habitat-Habitat Areas of Special Concern (EFH-HAPC) for the snapper-grouper complex.

C.1.1.5.2 Caloosahatchee River and Estuary

This portion of the study area is within the jurisdiction of the Gulf of Mexico Fishery Management Council (GMFMC) and is located in areas designated as EFH for juvenile brown shrimp, juvenile gray snapper, juvenile pink shrimp, adult and juvenile redfish,, adult and juvenile Spanish mackerel (*Scomberomorus maculatus*), and juvenile stone crab. Downstream habitats include oyster reefs and seagrass.

C.1.1.5.3 Biscayne Bay and Florida Bay

This portion of the study area is within the jurisdiction of the SAFMC and is located in areas designated as EFH for corals, coral reef and live bottom habitat, red drum, penaeid shrimps, spiny lobster, and other coastal migratory pelagic species and the snapper-grouper complex. Species generally present in the southern estuaries region include brown shrimp, pink shrimp, white shrimp, spiny lobster, stone crab, gulf stone crab (*Menippe adina*), redfish, Spanish mackerel, and gray snapper. Essential fish habitat in the southern estuaries is comprised of seagrasses, estuarine mangroves, intertidal flats, the estuarine water column, live/hard bottoms, and coral reefs.

C.1.1.6 Climate

The subtropical climate of south Florida, with its distinct wet and dry seasons, high rate of evapotranspiration, and climatic extremes of floods, droughts, and hurricanes, represents a major physical driving force that sustains the Everglades while creating water supply and flood control issues in the agricultural and urban segments.

Seasonal rainfall patterns in south Florida resemble the wet and dry season patterns of the humid tropics more than the winter and summer patterns of temperate latitudes. Of the 53 inches of rain that south Florida receives on average annually, 75% falls during the wet season months of May

through October. During the wet season, thunderstorms that result from easterly tradewinds and land-sea convection patterns occur almost daily. Wet season rainfall follows a bimodal pattern with peaks during May through June and September through October. Tropical storms and hurricanes also provide major contributions to wet season rainfall with a high level of interannual variability and low level of predictability. During the dry season (November through April), rainfall is governed by large-scale winter weather fronts that pass through the region approximately weekly. However, due to the variability of climate patterns (La Niña and El Niño), dry periods may occur during the wet season and wet periods may occur during the dry season. Multi-year high and low rainfall periods often alternate on a time scale approximately on the order of decades (USACE 1999).

High evapotranspiration rates in south Florida roughly equal annual precipitation. Evapotranspiration removes between 70% and 90% of the rainfall in undisturbed south Florida wetlands (Duever et. al. 1994). Evaporation from open water surfaces peak annually in the late spring when temperatures and wind speeds are high and relative humidity is low. Evaporation is lowest during the winter when the temperatures and wind speeds are low (Duever et. al. 1994). Recorded annual rainfall averaging 53 inches in south Florida has varied from 37 to 106 inches, and interannual extremes in rainfall result in frequent years of flood and drought. Mean sea level is increasing an average of 2.2 mm/year or approximately nine inches over the last 100 years in Florida (NOAA 2001).

Mean annual temperature for the south Florida ecosystem ranges from 72 ° Fahrenheit (F) (22 ° Celsius (C)) in the northern Everglades to 76 ° F (24 °C) in the southern Everglades (Thomas 1974). Mean monthly temperatures range from a low of 63° F (17 °C) in January to a high of 85 ° F (29 ° C) in August (Thomas 1974). Infrequently, freezing temperatures and frost occur when arctic air masses follow winter cold fronts into the area.

C.1.1.7 Physical Landscape: Regional Soils and Geology

This section presents the subsurface data necessary to effect the most practicable and efficient construction of works within the area of investigation. Some geologic data has been obtained from previous core borings and probings along all levee alignments in the agricultural and conservation areas south and east of Lake Okeechobee. Specific areas of focus in this report are study areas north of the EAA, between the Red, Blue, and Yellow Line, and slightly south of the Blue Line. Levee L-28 will serve as the western boundary of the project features. Soil types and their locations within the project area were determined from laboratory tested samples. This data, along with descriptions and recommendations to the geologic feasibility of construction in these areas, are presented in this section. Geotechnical investigations in the vicinity of current features are sparse, with nothing more recent than information gained from the EAA A-1 Reservoir Area studies performed in 2006. The design values are tentative, and characterization of the subsurface materials is valid only for preliminary estimation and analysis purposes. A complete and thorough analysis of the subsurface conditions during the Pre-Construction Engineering and Design (PED) phase will be required based on the results of a new, design level, geotechnical exploration program.

C.1.1.7.1 Soil Types

The soils in the Everglades are primarily composed of peats and mucks. Deep, clean sands characterize the area east of the Everglades and to the south of Lake Okeechobee with wet, gray or grayish-brown, sandy soils underlain by sandy clay cover the area west of the Everglades. The peat and muck soils, which are dark brown to nearly black, cover approximately 90% of the area being

considered in the study area. They were formed in marshes or swamps by the partial decay of plant materials, with some mixture of mineral soil in the case of muck. Peat, by definition, consists of 65% or more organic material with relatively little mineral matter. Muck on the other hand, consists of 25 to 65% plant material mixed with sand, silt, and clay. The peat and muck soils may differ from each other in the kind of plant material that they contain, in the corresponding depths, and/or in the nature of the underlying material. The peat and muck may rest directly on limestone or on an intermediate layer of sand or marl.

The highly organic soils have been divided into four types: Okeechobee muck, Okeelanta peaty muck, Everglades peaty muck, and Everglades peat. Okeechobee muck is a nearly black mixture of organic material and fine mineral soil. The organic portion of the soil is formed from the remains of water plants, while the mineral content probably results from the deposition of fine sediment during overflows from Lake Okeechobee. Okeelanta peaty muck consists of finely fibrous, well-decomposed organic matter over a layer of black plastic muck; it usually overlies hard limestone. Everglades peaty muck contains somewhat less mineral matter than Okeelanta peaty muck. The surface layer rests on brown, fibrous peat, and it usually lacks the subsurface layer of black plastic muck. Everglades peat, the most extensive of the organic soils, is formed mostly from partially decayed sawgrass. The upper 12 inches is a nearly black, finely fibrous peat which contains approximately 10% mineral soil. The subsoil is brown, fibrous peat which rests on the underlying rock, sand, or marl. A fifth type of organic soil, which is not extensive in the area, is Loxahatchee peat. It is a brown, spongy peat, composed of the remains of water lilies, water grasses, and other aquatic plants. Ordinarily, the area occupied by Loxahatchee peat is covered by water most of the year.

Most of the characteristics, properties, and composition of the muck and peat soils depend on the fact that those types of soils are essentially mixtures of water and partly decomposed plant materials. When saturated, the soil is a little heavier than water. One of the outstanding characteristics of the peat soil is its light weight when dry. The oven-dry weight of peat is about 7 pounds per cubic foot, and the mineral content is about 10 to 15% by weight of the dry material. Another important property is the high shrinkage value. Peat soils will shrink as much as 75% of their original volume when dried, and will not expand to their original volume when water is added.

Another important property is their high propensity for water retention. Peats vary considerably in that respect, depending on their origin, degree of decomposition, and chemical composition. While a dry mineral soil will absorb and hold from one-fifth to two-fifths its weight of water, a peat soil will retain many times its dry weight of moisture, depending on conditions. On an oven-dry weight basis, some of the peats have as much as 1,200% water when saturated, with the average having about 750%.

Laboratory permeability tests and field pumping tests indicate that seepage through peat soil is much greater vertically than horizontally. That can reasonably be attributed to the fibrous nature of the soil and its characteristic vertical root channels. Peat and muck material presented in less recent geotechnical exploration reports provide a general idea of the thickness of organic surface materials in the region. However, there are selected areas where the organic soil has been reduced due to recent construction, development, fire, erosion, compression, or removal. In other areas, there may be accretion of organic materials.

Where peat is encountered in a borrow area within the project area, it would be removed and not used as construction material. The available geotechnical information indicate suitable materials for embankment construction and other fills, mainly interbedded sands and/or marls with limestone, are available throughout the project area. In some areas, in-situ materials may have to be processed to achieve feature performance requirements.

Seepage movement in the Everglades is largely through the porous rock and sands beneath the peat. The sands, in general, are fine-grained and poorly graded having intermediate coefficients of permeability. The marl soils are widely distributed under the organic soils, and in places are consolidated into a hard limestone just under the peat. Usually, however, the marl is a soft, grayish-white, calcareous silt of fresh-water origin. Other marls, with inclusions of sand, silt, clay, and shell, appear within the area. The marl is not uniformly distributed and it often pinches out into the peat and muck. Generally it is quite impermeable, acting as a seal that retards movement of water.

C.1.1.7.1.1 Field Explorations

Previous field explorations of soils in the vicinity of the study area consisted of undisturbed sample borings, drive sample borings, auger borings, disturbed sampling of blasted limestone, and general reconnaissance along levee alignments in the area of investigation. Field exploration core logs, field and laboratory test results and geotechnical information available at this time include:

1. EAA Reservoir A-1 Geotechnical Data Report of March 2006
2. C&SF Part I Agricultural and Conservation Areas
3. Supplement 1 – Geology and Soils, December, 1951
4. C&SF Part I Agricultural and Conservation Areas, Supplement 7 – Permeability Investigations by Well Pumping Tests, February, 1953
5. Report of Investigations No. 13 (RI-13), Water Resources of Palm Beach County, Florida, 1954,
6. USACE, WCA 3 DECOMP Status Report, Appendix A, February 2012
7. USACE, L-31N (L-30) Pilot Project Design Report, May 2009.
8. Wolf WPC, 2009, Draft Conceptual Geotechnical Data Report, Miami Canal Decompartmentalization, Contract W912EP-05-D-0009, Miami-Dade County, Florida.
9. Nodarse and Associates, 2000, Stormwater Treatment Area No. 3 and 4 East WCA-3A Hydropattern Restoration L-5 Canal, Boring Profiles.
10. U.S. Army Corps of Engineers, 2011b, Core Borings along L-5/L-4/L-23 Waterway
11. Water Conservation Area 3 Decompartmentalization (DECOMP) and Hydrologic Sheet Flow Enhancement Part 1Broward County, FL.

A geotechnical exploration specific to this project has not yet been initiated, but will be required and conducted during the PED phase. The data contained in previous reports, although dated, is useful for preliminary planning purposes.

C.1.1.7.1.2 Laboratory Investigations

Samples of typical materials, obtained during the field exploration program, were tested by the South Atlantic Division (SAD) laboratory, and private Architect/Engineer (A/E) laboratories for classification and determination of physical properties. Unit weight, specific gravity, ignition loss and mineral content, grain-size distribution, and maximum density and optimum moisture are available in C&SF Part I Supplement 1.

C.1.1.7.1.3 Office Analysis

Previous analyses of existing conditions are available in the C&SF Part I Agricultural and Conservation Areas, Supplement 1 – Geology and Soils, December, 1951. A seepage analysis for the Flow Easement Basin (FEB) is contained in this section.

C.1.1.7.1.3.1 Everglades Agricultural Area

The subsurface soil conditions at the FEB and nearby areas are most closely approximated by the subsurface conditions in the adjacent EAA Reservoir A-1. The EAA Reservoir A-1 Project site has been investigated in a progressive sequence of borings spaced throughout the site area. One hundred forty-five borings were completed for the SFWMD around the reservoir perimeter in 2003 and early 2004. Twenty borings to a depth from 50 to 100 ft below ground surface (bgs) were completed at the EAA Reservoir A-1 Project Test Cell site for the Test Cell Project design in December 2004, and an additional eight borings were completed during the Test Cell construction in early 2005. The borings generally penetrated through about 1/2 to 2 feet of surficial peat/muck and marl, then through 22 to 26 feet of primarily carbonate sand and limestone, and then into primarily shelly quartz sand with sparse limestone to their completed depths. The upper carbonate sand and limestone constitutes the Fort Thompson Formation at the site. Below this, the shelly sand and sparse limestone constitutes the Caloosahatchee Formation and possibly part of the Tamiami formation. The top of the Fort Thompson Formation consists of a limestone layer about 4.5 to 5 ft thick, which is locally called caprock. The caprock is generally white, light gray, tan or yellowish brown with variable amounts of weathering; it is occasionally fractured and contains voids and inconsistencies. The caprock is underlain by a silty carbonate sand extending to about 23.5 to 24.5 ft deep, where another hard limestone layer 1.5 to 3 ft thick is encountered. A thinner, hard limestone layer about 1/2 to 1 foot thick is often encountered at around 16 to 17 feet deep. The sand and lower limestone layers are generally white to very pale brown. Laboratory testing of the sand sampled in the borings averaged 84.2% calcium carbonate content with an average of 22% passing the #200 sieve in gradation tests. Visual inspection of the sand samples from the borings reveals that they include shell fragments, and tend to be angular and platy. The sands of the Fort Thompson Formation exposed in the seepage collection canals and dewatering sumps is abundantly fossiliferous with gastropods, pelecypods, corals, and echinoderms.

The top of the Caloosahatchee Formation is composed of fine grained, subrounded, shelly quartz sand that is mixed with shelly carbonate sand similar to that in the Fort Thompson Formation. The Caloosahatchee Formation at the site is 30 to 60 ft thick; however, the interface between this formation and the underlying Tamiami Formation is difficult to define. The proportions of carbonate to quartz sand vary. Laboratory testing on the sampled sand indicated an average calcium carbonate content of 30.1%, and an average 12.1% of material passing the #200 sieve. The primary color of the geologic material in the Caloosahatchee Formation is light greenish gray.

Preliminary estimates of soils engineering properties of materials in the EAA/FEB area and features north of the red line are derived from previously referenced documents and are summarized in **Table C.1-1**.

Table C.1-1. Preliminary Soil Properties for the CEPP

Location	Organic Materials					Sands**			
	Specific Gravity	Unit Weight (lb/ft^3)	Natural Moisture (%)	Organic Matter (%)	Mineral Content (%)	Moist Weight (lb/ft^3)	Buoyant Weight (lb/ft^3)	Effective Friction Angle (degrees)	Cohesion (lb/ft^2)
Region: EAA, FEB Areas – North of Red Line									
Levees L-4 and L-5	1.54	58	779	89	11	109.5	62.9	35	0
Levees Southeast of Lake Okeechobee (near Levee L-8)	1.46	60	436	91	9	-	-	-	-
Levees L-6 and L-7	1.5	61	920	93	7	-	-	-	-
Region: DECOMP – L-67A/C, L-5 Areas - Areas South of the Red Line and North of the Blue Line.									
Areas Below the Red Line to the Blue Line-Levees L-28 and L-29	1.94	62	479	52	48	109.5	62.9	35	0
Area of Levee L-30- Along the Yellow Line	1.5	60	686	75	25	110	62.8	38	-
Areas Near Levees L-33 and L-37	1.58	62	430	85	15	110	62.8	38	-
Limestone tested in the vicinity of L-30 and L-37**	-	-	-	-	-	122.3	-	38	980

*Values are averages from results of Laboratory Tests from the 1951 Supplement 1 Report

**All material properties are for sands except for limestone as noted

C.1.1.7.1.3.2 L-67A/C, L-5 Areas

All of the recent and previous geotechnical investigations concentrated on the levee areas of WCA 3 which includes WCA 3A and WCA 3B, and not in the undisturbed areas of WCA 3 where the soils are situated. Within WCA 3, the majority of the soils are histosols which includes Everglades peats and Loxahatchee peats. Everglades peats are typically brown to black with minimal mineral content. Loxahatchee peats are found in topographic low areas and are composed of the remains of the roots and rhizomes of Nymphea, a white water lily. The western margin of WCA 3A is mixed marl peats that are derived from the underlying limestone Based on the information provided by standard penetration test borings, continuous core boring, and test pit excavations, the subsurface stratigraphy at WCA 3A is summarized below based on the 2000 geotechnical investigation by Nodarse (Nodarse, 2000) the March 2011 geotechnical investigation conducted by USACE personnel (USACE, 2011b), and Wolf personnel (Wolf WPC, 2009):

1. Layer 1 - Fill: This layer consists of localized areas of fill adjacent to existing canals at the time of the construction of these canals. The material is predominately sandy fill with some gravel, trace clay, some gravel and some shell in the northern hydropattern restoration area (L-4 and L-5). By the Miami Canal (L-23) in Broward County the fill is predominately limestone (crushed rock) fill. Both materials vary in thickness from 0.5 ft to 6 ft. The fill has standard penetration N-values between 8 and 84 blows per foot in the hydropattern restoration area, depending upon the degree of material compaction. If groundwater is present in the fill, it normally occurs between 2 and 4.5 ft below grade.
2. Layer 2 - Interbeds of Organic Sand and Clay Including "Peaty" Clay: This layer consists of alternating beds of organic sand and clay. The sand unit is predominately well-graded (poorly sorted) with some shell fragments and trace clay. Thickness ranges from 0.1 to 9 ft. In the northern hydropattern restoration area, standard penetration test N-values vary between 2 and 68 blows per foot. The clay unit has trace gravel, sand and some shell fragments. In some places, the clay unit is carbonaceous or "peaty" (fibrous) and in some places, "fat" clay is present. Thickness ranges from 0.2 to 4.5 ft for the clay unit. Standard

penetration N-values range from 0 to 11 blows per foot in the northern hydropattern restoration area. In Broward County this clay unit appears to be laterally continuous. If groundwater is present, it occurs between 6.6 and 8.5 ft below grade within these units.

3. Layer 3 - Limestone: Underlying the unconsolidated material of fill/organic sand and clay is limestone that is fossiliferous, vuggy, and moderately to intensely weathered that is also slightly to highly fractured. Clay infilling of the voids is apparent in some areas. No unconfined compressive strength tests were conducted. Rock quality designations ranged from 0 to 77% with an average value of 25 percent. In some places, the limestone is interbedded between the organic sand/clay units.

Previous geotechnical data compiled by Nodarse and Associates in 2000 are summarized below for the L-5 area for comparison with the WCA 3 data above:

1. Layer 1 fill parameters: Standard penetration test N-value – 18 to 67 blows per foot.
2. Layer 2 Sand/Clay/Peat parameters: Peat-N values ranged from 1 to 10 blows per foot, clay N values ranged from 1 to 6 blows per foot, and sand N values ranged from 10 to 40 blows per foot.
3. Layer 3 Limestone Parameters: Standard penetration test N –values of 50 blows per 0" to 50 blows per 8"and rock quality designations (RQD): 0 to 17 percent.

Preliminary estimates of soils engineering properties of materials in the DECOMP WCA 3 and L-5 Areas, as well as features south of the EAA and north of Tamiami Trail, are derived from previously referenced documents and summarized in **Table C.1-1**.

C.1.1.7.1.3.3 L-31N Area

The high transmissivity of the Biscayne Aquifer allows for rapid recharge of the Lower East Coast (LEC) well fields, while promoting significant hydro-geologic interaction between the Everglades and Biscayne Bay. The LEC area is located to the east of the L-31N, L-31W, and C-111 canals. The end result is the need for seepage management. The LEC on the Atlantic Coastal Ridge is mostly underlain by thin sand and Miami Limestone that are highly permeable and are moderately to well drained. To the west of the coastal ridge, soils of the LEC contain fine and loamy material, and have poor natural drainage. Rockland areas on the coastal ridge in Miami-Dade County are characterized by weathered limestone surfaces and karst features such as solution holes and sinkholes. Higher elevation marshes of the southern Everglades, on either side of Shark River Slough, are characterized by calcitic marl soils deposited by calcareous algal mats and exposed limerock surfaces with karst features, such as solution pits and sinkholes. In agricultural areas of Miami-Dade County, it is common to encounter mixed soils called "rock plowed" soil, such as Chekika and Krome. This soil is a manmade material created by farmers excavating and crushing the soft underlying Miami Limestone, and mixing/tilling it along with the natural overburden soils.

Consequently, the overburden thickness is somewhat higher in these areas. In most cases, the underlying Miami Limestone controls the infiltration of rain or introduced stormwater due to the high permeability of the rock-plowed soils. These rock-plowed soils have very gravelly textures (34-76% limestone fragments, 2 mm or larger in diameter), and their organic content is usually less than 2%. West of L-31N, muck and marl predominate. The muck and marl soils have been classified as hydric soils. A hydric soil refers to "a soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part of the soil profile that favor the growth and regeneration of hydrophytic vegetation." In addition, there are areas where rock outcrops or weathered rock surfaces occur. Rock outcrops are characterized by karst features such

as solution pits, caves, and sinkholes, leaving a rock surface that is extremely rugged and pitted. Pits in the rock surface range from several inches to several ft in diameter and depth. Where soil development has occurred on these surfaces, soils are primarily entisols, but may also include alfisols and histosols. The Miami Limestone is a thin, wedge-shaped limestone layer 20 ft in thickness near the Florida Turnpike, and 12 ft thick along the L-31N Levee This very porous limestone is marked by numerous vugs that is soft to moderately hard, moderately to highly weathered, thick bedded with occasional cross bedding, white to yellow, and riddled with solution cavities. The solution cavities are typically filled with loose sands and peat. Below the Miami Limestone and the Fort Thompson Formation consist of alternating layers of shallow marine, brackish, and fresh water limestones comprised of thick units of soft to hard, moderately weathered, light gray, sandy, clayey limestone, and calcareous sandstone with a few thin beds of fresh water limestone. Underlying the Fort Thompson Formation is the Tamiami Formation, which is composed of two members in the area: (1) the Pinecrest Sands, and (2) the Ochopee Limestone. The Pinecrest Member lies below the Fort Thompson Formation and is comprised of quartz sand, reefal fragments, and sandstone that is moderately hard and creamy white to greenish gray with occasional soft layers of silty, clayey, shelly sands. The Ochopee Limestone is moderately to well-indurated, slightly phosphatic, occasionally sandy and fossiliferous (Scott, 1997).

Preliminary estimates of soils engineering properties of materials in the L-31N Area, and features south of Tamiami Trail and along the East Coast Protection Levee, are derived from previously referenced documents and summarized in **Table C.1-1**.

C.1.1.7.2 Geology

Surficial geology of the CEPP area of investigation consists of fossiliferous limestones interlayered with siliciclastic sediments that were deposited and reworked during Quaternary sea level fluctuations. Rocks formed in a shallow marine depositional environment under tropical and subtropical environmental conditions. Three geological formations comprise this sedimentary package: (1) the Pamlico Sand, (2) the Miami (Oolite) Limestone, (3) the Fort Thompson Formation, and (4) the Caloosahatchee Marl. This sedimentary package rests unconformably on quartz sands of the Pliocene Tamiami Formation, which serves as basement for this study. The areal distribution of geological formations that comprise this sediment package is shown in **Figure C.1-1**. The thickness of the sediment package increases north to south from approximately 40 ft at the boundary between the EAA and WCA 3A to approximately 100 ft at Tamiami Trail. This unit also forms an eastward thickening wedge toward the Atlantic Coast (Reese and Cunningham, 2000; Reese and Wacker, 2009). The Pamlico Sand forms a linear geomorphic feature called the Atlantic Coastal Ridge that extends from Palm Beach County to southern Miami-Dade County. However, the western margin of this feature generally follows the Florida Turnpike, and is not within the CEPP area of investigation.

The character of the marginal marine sediments changes from north to south. Near the boundary between the EAA and WCA 3A, the sediment thickness consists of poorly consolidated marine limestone, quartz sandstone, and sandy limestone with abundant mollusk fossils (Reese and Wacker, 2009), and is known as the Fort Thompson Formation. South of central Broward County to Tamiami Trail, the composition of the Fort Thompson Formation changes to predominantly marine limestones that were deposited in marine platform margin and open marine tropical conditions similar to those observed in the present-day southern Florida Keys. The oolitic Miami Limestone often outcrops at the surface near Tamiami Trail and forms approximately 10 to 15 ft of caprock overlying the Fort Thompson Formation. The Fort Thompson Formation is a karstic limestone in

southern Broward and Miami-Dade Counties, and has been characterized by Cunningham et al. (2006) into 16 distinct lithofacies representing freshwater, platform margin, ramp, and open marine carbonate depositional environments. Subsequent dissolution of these limestones during low sea levels resulted in the development of karst, with extensive vugs and conduits throughout the vertical sequence of rock. The gradation of lithologies, from mixed clastic-carbonate near the boundary between the EAA and WCA 3A to karstic marine carbonates at Tamiami Trail, affects the porosity and permeability of the sedimentary package.

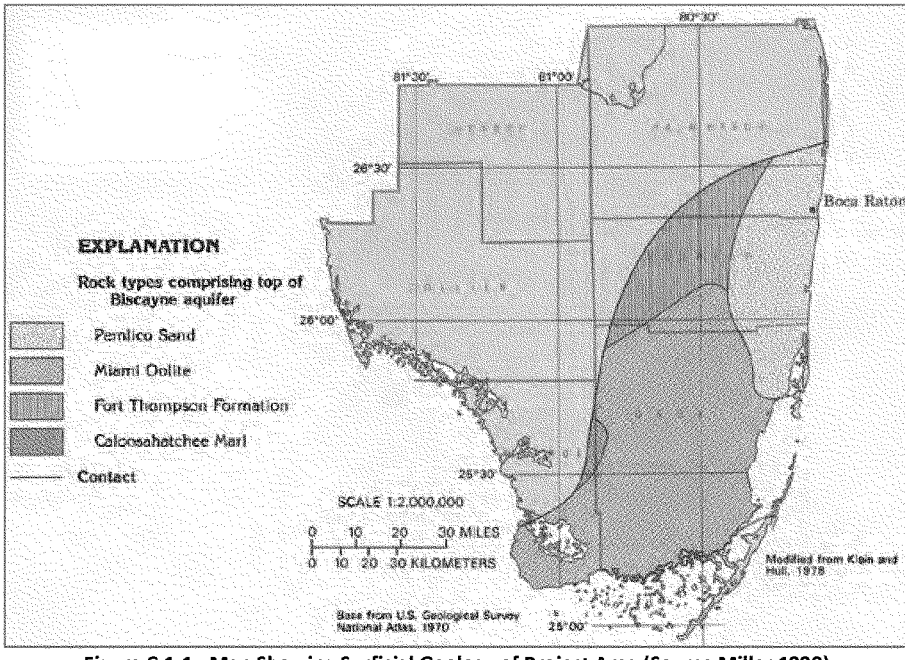


Figure C.1-1. Map Showing Surficial Geology of Project Area (Source Miller 1990)

C.1.1.7.3 Hydrogeologic Setting

The Fort Thompson Formation changes in texture and composition from north to south, with quartz sand and sandy carbonate more abundant in the area of the boundary between the EAA and WCA 3A, and marine carbonates dominating toward Tamiami Trail. The transition from sands to carbonate affects the permeability characteristics of the surficial aquifer system that is included within these sediments.

Near the boundary between the EAA and WCA 3A, Reese and Wacker (2009) recognize a major permeable zone within the Fort Thompson Formation (permeable zone 2), at depths less than 80 ft below land surface. This permeable zone is the upper portion of the surficial aquifer system of south Florida. Very large pore spaces are common, characterized by interconnected vugs or cavities. Estimated transmissivity from aquifer performance tests conducted in southwest Palm Beach County varies widely, between 30,000 and 60,000 ft^2/day (Reese and Wacker, 2009). Hydrologic data (estimates of transmissivity, storage coefficient and leakance) are sparse near the boundary

between the EAA and WCA 3A. Permeable zones in this area are not typically defined as the Biscayne Aquifer.

The Biscayne Aquifer is recognized as "the contiguous, highly permeable section of the Pliocene (Tamiami Formation) and Pleistocene age from land surface downward, where at least 10 ft of the section has a hydraulic conductivity of 1,000 ft/day or more" (Fish and Stewart, 1991). This aquifer underlies most of the CEPP area of investigation south of northern Broward County (**Figure C.1-1**). The Biscayne Aquifer is interpreted as a dual-porosity pore system, with matrix porosity providing water storage, and "touching vug" porosity forming preferential flow zones (**Figure C.1-2**; Cunningham et al., 2006; Renken et al., 2008). Measured permeability values from rock samples vary over 13 orders of magnitude (Sukop and Cunningham, 2011). The heterogeneous nature of permeability in the Biscayne Aquifer makes characterization of aquifer parameters difficult. Site-specific test borings and aquifer characterization are required to evaluate hydrologic characteristics.

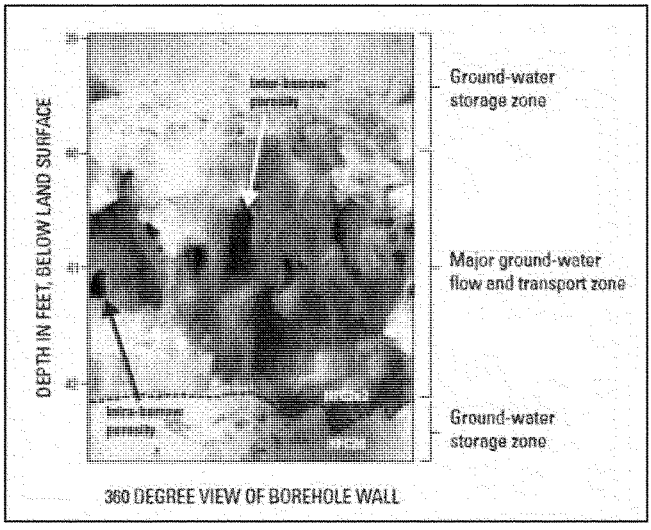


Figure C.1-2. Direct Image of Borehole in the Fort Thompson showing Dual Porosity of Biscayne Bay Aquifer (Well G-1386) (Source Cunningham et.al. 2006)

C.1.1.8 Hydrology

The major characteristics of south Florida's hydrology are: (1) local rainfall, (2) evapotranspiration, (3) canals and water control structures, (4) flat topography, and (5) the highly permeable surficial aquifer along a thirty to forty mile-wide coastal strip. Local rainfall is the source of all of south Florida's fresh water. The surface water that is not removed from the land by evapotranspiration and seepage to the underlying aquifer is drained to the Atlantic Ocean, Florida Bay, or the Gulf of Mexico by very slow, shallow sheetflow through wetlands or relatively quickly through man-made canals.

Levees and canals constructed during the last 60 years under the Central and Southern Florida (C&SF) Project have divided the former Everglades into areas designated for development and areas for fish and wildlife benefits, natural system preservation, and water storage. The natural areas

consist of the three WCAs located north of Tamiami Trail ENP to the south. The WCAs provide detention storage for water from Lake Okeechobee, the EAA, and parts of the east coast region. Detention of water helps prevent floodwaters from inundating the east coast urban areas; provides water supply and detention for east coast urban and agricultural areas and ENP; improves the water supply for east coast communities by recharging underground freshwater reservoirs; reduces seepage; and provides control for saltwater intrusion in coastal aquifers. While the WCAs may reduce the severity of the drainage of the Everglades caused by the major canal systems, thus reducing impacts to fish and wildlife caused by the major drainage systems, the levees surrounding the WCAs still function to impound the Everglades, precluding the historic flow patterns. The C&SF Project infrastructure makes it difficult to provide natural timing, volume and distribution. In wet periods, water is impounded in the WCAs and then discharged to ENP or coastal canals for eventual release to tide. During dry periods, water can flow through the canals to coastal areas and bypass the ENP wetlands.

Throughout CEPP formulation, C&SF infrastructure modifications to achieve CEPP project objectives have been primarily focused within WCA 3, and the hydrology of this area is discussed in greater detail than other areas more peripheral to CEPP formulation efforts.

C.1.1.8.1 Lake Okeechobee and the Northern Estuaries

Lake Okeechobee is a subtropical lake in south central Florida with a surface area of 730 square miles and an average depth of nine feet (ft). Lake Okeechobee is a major feature of the Kissimmee-Okeechobee-Everglades system, which is a continuous hydrologic system extending from central Florida south to Florida Bay. Lake Okeechobee provides a number of values to society and nature including water supply for agriculture, urban areas and the environment, flood protection, a multi-million dollar sport fishery, and habitat for many birds and animals, including endangered and threatened species.

Lake Okeechobee is managed as part of the C&SF Project for water supply and flood protection. The Herbert Hoover Dike (HHD) and several water control structures allow management of Lake Okeechobee to meet project purposes which include flood control, water supply, navigation, recreation, and environmental enhancement. Inflows to Lake Okeechobee average 2.1 million acre-feet per year. Nearly half the inflow to Lake Okeechobee is through the Kissimmee River. The Upper and Lower Kissimmee River watersheds cover more than 2,300 square miles of central Florida. The remaining inflow to Lake Okeechobee is received from Lake Istokpoga, Fisheating Creek, the Taylor Creek-Nubbin Slough Basin, and reverse flows from the Caloosahatchee River, the St. Lucie Canal, and the EAA.

The primary outflows from Lake Okeechobee are east to the St. Lucie Canal and west to the Caloosahatchee River. The main outflows south are through the Miami Canal, North New River Canal, Hillsborough Canal, and the West Palm Beach Canal. Inflows to Lake Okeechobee frequently exceed total outflow capacity. The approximately 35-mile St. Lucie Canal, part of the Okeechobee Waterway, is the main eastern flood control outlet for Lake Okeechobee. The St. Lucie Estuary is located within portions of both Martin and St. Lucie counties on the southeast coast of Florida. The two forks of the St. Lucie Estuary, the North Fork and South Fork, flow together near the Roosevelt Bridge at the City of Stuart, and then flow eastward approximately six miles to the Indian River Lagoon and Atlantic Ocean at the St. Lucie Inlet. The Caloosahatchee River, part of the Okeechobee Waterway, is the only flood control outlet leading west from Lake Okeechobee. Combined with the St. Lucie Canal and Lake Okeechobee, the Caloosahatchee River completes the only navigable

passage between the Gulf of Mexico and the Atlantic Ocean. The river extends approximately 70 miles from Lake Okeechobee, through the Caloosahatchee Estuary, to the lower Charlotte Harbor Basin at San Carlos Bay. The Caloosahatchee River passes through parts of Glades, Hendry, and Lee counties.

Water management decisions regarding Lake Okeechobee are highly dependent upon the HHD. The HHD is an approximately 70-year-old earthen levee that was constructed around the southern portion of Lake Okeechobee for flood control purposes. Heightened concern with the structural integrity of the HHD was emphasized after several hurricanes passed through south Florida during 2004 and 2005, as well as consideration of the levee damage around New Orleans caused by Hurricane Katrina in 2005. Prior to these devastating hurricanes, the USACE conducted a lengthy study of the HHD condition which resulted in a 1999 report titled "Major Rehabilitation Evaluation Report" (MRR). This report documented the condition of the dike, and identified needed repairs. In response to the findings in the MRR and associated Reach 1 EIS (USACE 2005), a Major Rehabilitation Project was approved, and HHD rehabilitation is currently underway. In April 2008, the 2008 Lake Okeechobee Regulation Schedule (2008 LORS) was implemented in response to high lake levels that resulted in integrity issues and concerns with the HHD, high volume releases to the estuaries, and impacts to Lake Okeechobee littoral zones. The 2008 LORS attempts to manage Lake Okeechobee water levels between 12.5 and 15.5 ft National Geodetic Vertical Datum 1929 (NGVD) throughout the year in an effort to balance competing objectives including flood control, water supply, navigation, and enhancement of fish and wildlife resources. LORS 2008 was determined to represent the best operational compromise at the time to improve the environmental health of certain major ecosystems, while providing for public health and safety as it pertains to the HHD. The USACE expects to operate under the interim 2008 LORS schedule until the earlier of (1) implementation of a new Lake Okeechobee schedule as a component of the system-wide operating plan to accommodate the Comprehensive Everglades Restoration Plan (CERP Band 1 projects) and the State of Florida's fast track Acceler8 projects, or (2) completion of HHD seepage berm construction or equivalent dike repairs for reaches 1, 2 and 3.

C.1.1.8.2 Everglades Agricultural Area

The EAA is located south of Lake Okeechobee primarily in western Palm Beach County, extending south to WCA 3A. It is bounded on the east by the WCA 1, WCA 2A, the Western C-51 Basin, the L-8 Basin, and on the west by the C-139 Basin. Historically, the EAA was swampland before it was drained and put into agricultural production. The former swampland produced the rich organic peat and muck soils that today make it a highly productive agricultural area, with approximately 620,000 acres of agricultural land. The agricultural area designation was formally established in the 1950s and associated water management infrastructure had been substantially completed in 1962.

Water in the EAA is managed to provide flood protection, irrigation, and fresh water for the EAA and surrounding environmentally sensitive areas through a series of canals, levees, culverts, gates, and pumps. The larger primary canals within the EAA are managed by the SFWMD and convey water from Lake Okeechobee and the EAA to the WCAs and other downstream areas/users and/or to nearby coastal waters. Primary canals in the project area include the L-1, L-2, and L-3 Canals that form the west boundary of the EAA; the Hillsboro Canal; the North New River Canal; the West Palm Beach Canal; the Miami Canal, and the L-8 Canal that forms the eastern boundary of the EAA. Smaller secondary canals are also managed by the SFWMD and connect the primary canals. The connections may be open or may have water control structures. Secondary canals in the project area include the Bolles (L-21), Cross (L-16), Ocean (L-13), and L-1 East Canals. Small, numerous

agricultural canals (usually unnamed) are the responsibility of the individual landowners and are used to provide water management of adjacent individual farming operations.

Stormwater runoff from the EAA, which contains relatively high levels of nutrients (mainly phosphorus and nitrogen from particulate matter and fertilizers), drain from the agricultural canals, to the secondary canals, into the six main primary canals, and are eventually discharged into the EPA or to tide. In addition to flood protection for and water supply to the EAA, the canals and water control structures convey regulatory releases from Lake Okeechobee to the WCAs; water supply releases to the EAA and eastern Palm Beach, Broward, and Dade Counties for municipal water supply and to prevent saltwater intrusion; and water supply releases to ENP. There are eight existing Stormwater Treatment Areas (STA 1E, STA 1W, STA 2, STA 3/4, STA 5, STA 6, Compartment B, and Compartment C) that capture the majority of water in the primary canals for biological water quality treatment prior to discharge into the WCAs. For additional information regarding the hydrology of the STAs, refer to the USACE January 2009 Final EIS to Construct Stormwater Treatment Areas on Compartments B and C of the Everglades Agricultural Area.

C.1.1.8.3 Water Conservation Area 1

WCA 1, also known as the Arthur B. Marshall Loxahatchee National Wildlife Refuge (LNWR), is approximately 21 miles long from north to south and comprises an area of approximately 221 square miles. The West Palm Beach Canal lies at the extreme northern boundary, and on the south, the Hillsboro Canal separates WCA 1 from WCA 2A. Ground elevations slope approximately five feet in ten miles, both to the north and to the south from the west center of the area, varying from over 16 feet in the northwest to less than 12 feet NGVD in the south. The area, which is enclosed by approximately 58 miles of levee, approximately 13 miles of which are common to WCA 2A, provides storage for excess rainfall runoff from areas that drain to EAA canals, the West Palm Beach Canal (230 square miles) and the Hillsboro Canal (146 square miles). In addition, WCA 1 may receive water from Lake Okeechobee under certain conditions. Discharges from WCA 1 to meet water supply demands can occur to the West Palm Beach Canal, Hillsboro Canal, and the canal infrastructure east of WCA 1, in accordance with the WCA 1 Regulation Schedule (USACE 1996). The WCA 1 Regulation Schedule also defines when excess water in WCA 1 can be discharged to WCA 2A and to tide via the Hillsboro Canal. Due to its limited discharge capacity and its relatively small size compared to the watershed from which it receives water, consecutive rainfall events have the potential to quickly utilize storage within WCA 1, resulting in discharges from WCA 1 to WCA 2A via the S-10 structures.

C.1.1.8.4 Water Conservation Areas 2A and 2B

Covering an area of 210 square miles, WCA 2 is comprised of two areas, 2A and 2B, and measures approximately 25 miles from north to south. WCA 2A is separated from the other WCAs by the Hillsboro Canal to the north and the North New River Canal to the south. Ground elevations slope southward approximately two to three feet in ten miles, ranging from over 13 feet NGVD in northwest WCA 3A to less than 7 feet NGVD in southeast WCA 3B. The area is enclosed by approximately 61 miles of levees, of which approximately 13 miles are common to WCA 1 and 15 miles to WCA 3.

The upper pool, WCA 2A, provides an area of approximately 173 square miles for storage of excess water from WCA 1 and a portion of the EAA (125 square miles) which drains to the North New River Canal. Water supply to the east coast urban areas of Broward County is provided by WCA 2A, in accordance with the WCA 2A Regulation Schedule (USACE 1996). Due to its limited discharge capacity and its relatively small size compared to the watershed from which it receives water,

consecutive rainfall events have the potential to quickly utilize storage within WCA 2, resulting in discharges from WCA 2A to WCA 3A via the S-11 structures.

Ground elevations in WCA 2B range from 9.5 feet NGVD in the northern portions to seven feet NGVD in the southern portions of the area. The area experiences a high seepage rate, which does not allow for the long-term storage of water, and as a result, water is not typically released from WCA2 B.

C.1.1.8.5 L-28 Triangle

The L-28 Triangle (Triangle) area is located entirely within the boundaries of the Miccosukee Tribe of Indians of Florida's Alligator Alley Reservation and encompasses 7,830 acres of Tribal lands and approximately 230 acres of Big Cypress National Preserve (BCNP). The L-28 Triangle area is confined on north by Interstate 75, the west by L-28 Interceptor Canal (L-28I) and the BCNP, and the east by the L-28 Canal.

The L-28 Interceptor Canal is bound by levees on both sides and maintains no direct connection to wetlands in the Triangle. Within the L-28 Triangle Area, the L-28 Canal is bound on the east side by a confining levee separating the wetlands of the L-28 Triangle from WCA 3A. Wetlands interior to the L-28 Triangle do maintain a connection to the L-28 canal along the west side of the L-28 canal. The L-28 canal terminates at the southern tip and is not connected to the L-28 canal. Historically the S-140 pump station maintained flood protection within the Triangle. A weir was installed in 2009 within the L-28 Canal and immediately south of Interstate 75 to restrict regional pumping and maintain water levels within the Triangle.

C.1.1.8.6 Big Cypress National Preserve

The BCNP spans approximately 1,205 square miles from southwest of Lake Okeechobee to the Ten Thousand Islands in the Gulf of Mexico. The 1,125 square miles of the BCNP was originally created in 1974 by Public Law (PL) 93-440 and subsequently expanded in 1988 by the Big Cypress National Preserve Addition Act. BCNP was established to protect natural and recreational values of the Big Cypress watershed to allow for continued traditional uses, such as hunting, fishing, and oil and gas production, and to provide an ecological buffer zone and protect the water supply to ENP. BCNP is a large, flat area with maximum elevations of 22 feet NGVD in the northern region which gradually slope south to sea level in the BCNP coastal region along the Gulf of Mexico.

The L-28 Levee presently separates WCA 3A and the BCNP. Surface water flows from BCNP are introduced to WCA 3A from Mullet Slough; WCA 3A is also hydrologically connected to BCNP through three degraded gaps along the northern tie-back of the L-28 Levee and seasonally through water management operations of S-343A, S-343B, and S-344 along the southern L-28 Levee. Surface water flows introduced to the L-28 Canal from these three structures and upstream inflows to BCNP from the L-28 gaps may additionally contribute to deeper water depths and prolonged hydroperiods within the western portion of the CSSS-A habitat, as this water is directed south to the Tamiami Trail section between the Forty-mile bend (located west of S-12A) and Fifty-mile bend. Tamiami Trail and Loop Road, which include bridges and culvert connections to allow southerly flow west of Forty-mile bend, also affect hydropatterns within southern BCNP.

C.1.1.8.7 Water Conservation Areas 3A and 3B

The largest WCA is WCA 3, which is divided into two parts, 3A and 3B. It is approximately 40 miles long from north to south and covers approximately 915 square miles. Ground elevations slope

southeasterly one to three feet in ten miles ranging from 13 feet NGVD in northwest WCA 3A to six feet NGVD in southeast WCA 3B. The area is enclosed by approximately 111 miles of levees, of which 15 miles are common to WCA 2. An interior levee system across the southeastern corner of the area reduces seepage into an extremely pervious aquifer.

The upper pool, WCA 3A, provides an area of approximately 752 square miles for storage of excess water from WCA 2A; rainfall excess from approximately 750 square miles in Collier and Hendry counties (through Mullet Slough), and from 71 square miles of the former Davie agricultural area lying east of Pump Station S-9 in Broward County; and excess water from a 208 square mile agricultural drainage area of the Miami Canal and other adjacent areas to the north. WCA 3A provides water supply to the Lower East Coast (LEC) as well as the South Dade Conveyance System (SDCS) in accordance with the WCA 3A Regulation Schedule and provides water supply to ENP in accordance with the Rainfall Plan and the WCA 3A Regulation Schedule (USACE 2006). Due to its limited discharge capacity compared to the watershed from which it receives water, consecutive rainfall events have the potential to quickly utilize potential storage within WCA 3A resulting in discharges from WCA 3A to SRS and/or the South Dade Conveyance System (SDCS) via the S-12 structures and/or S-333 and S-334.

The outer perimeter levees of WCA 3 are the L-4, L-5, L-38 (separating WCA 3 from WCA 2A and WCA 2B), L-37, L-33, L-30, L-29 and L-28 (southern L-28, south of Mullet Slough, contains three gaps to allow for natural drainage from Collier County to the west). Interior parallel levees, L-67A and L-67C, along with their associated borrow canals subdivide WCA 3 into two parts: WCA 3A and WCA 3B. The L-67A and L-67C levees were originally constructed (completed in 1962 and 1966, respectively) for several reasons, including as a step-down system to reduce seepage to the east to allow for urban and agricultural developments in Miami-Dade County, and to increase storage of water in WCA 3A to provide water supply to an expanding urban population to the east. The construction of Tamiami Trail and WCA 3 impounded and altered the historic SRS, effectively creating a barrier through the Everglades, between the northern Everglades (i.e. WCAs) and ENP. The Miami Canal extends from Lake Okeechobee to the Atlantic Ocean and crosses WCA 3 from northwest to southeast. To remedy excessive drainage caused by the Miami Canal, two structures, S-339 and S-340, were built across the C-123 Canal to block water from flowing directly down the canal, except at times of extreme high water or when increased conveyance capacity is needed to deliver water for the ENP and/or the LEC. Upstream from each structure, water was expected to flow laterally from the canal into the marsh through 100 foot gaps that had been left at 500 foot intervals in the canal's spoil piles. South of WCA-3 and within ENP, the northern portion of SRS is also partially divided by the remaining 5.5 miles of the L-67 Extension Levee, which extends south from the southern terminus of L-67A at Tamiami Trail. Outflows from WCA 3A to ENP are regulated according to the WCA 3A Regulation Schedule, with some additional WCA 3A outflows to ENP from groundwater seepage across Tamiami Trail and seasonal surface water flows through the L-28 gaps, which then continue south along the L-28 borrow canal.

Stage variability within WCA 3 typically follows an annual cycle; the levels vary from high stages in the late fall and early winter to low stages at the beginning of the wet season (typically late May or early June). The cycle is primarily driven by rainfall, though it is also heavily influenced by water management operations designed to maintain congressionally authorized project purposes, including water supply to the LEC and ENP and flood protection to the adjacent EAA and LEC, as well as protection for tropical cyclone events and other extreme storm events. The annual cycle permits the storage of runoff during the wet season and the release of stored water to ENP during the dry

season and maintains elements of the habitat essential to fish and wildlife. The distribution of water for flood control and water supply varies seasonally. The regulation schedules for the WCAs include a minimum water level, below which water releases are not permitted unless water is supplied from another source.

Overall, water stage decreases from northwest to southeast within WCA 3, consistent with the general direction of surface water flow and prevailing topography within WCA 3. Water depth is typically between one to two and a half feet, with the shallower waters in the higher elevation northwestern portion of WCA 3. Water stages and depths in WCA 3B are typically much lower than water stages and depths in WCA 3A, due to limited surface water inflows into WCA 3B and the reduction of seepage from WCA 3A to WCA 3B due to the design of L-67A and L-67C levees. Water levels in WCA 3B are affected by seepage losses to the east towards the L-30 borrow canal and to the south towards the L-29 Canal.

Water supply deliveries from the C&SF Project (also known as the Regional system) to coastal canals are utilized to recharge coastal well fields. When canal levels drop below adequate recharge levels due to a combination of wellfield drawdowns, evaporation, and lack of rainfall, water supply deliveries are typically made from the Regional system. When canal levels drop in Miami-Dade County, regional water supply is delivered from WCA 3A through one of two delivery routes. Depending on system conditions, both routes may be utilized concurrently. For the northern delivery route from WCA 3A, water supply deliveries are either released from S-151 to the Miami Canal within WCA 3B (C-304), followed by downstream releases to either Miami-Dade County's SDCS by utilizing S-337 and/or by utilizing S-31 to release into the C-6 Canal. For the southern delivery route from WCA 3A, water supply deliveries are released from S-333 (from the upstream L-67A Canal), pass through the L-29 Canal, and are released to the SDCS by utilizing S-334.

If WCA 3A levels are at or below the 7.5 feet NGVD minimum, or WCA 3A floor level, then water supply releases from WCA 3A must be offset by equivalent inflows to WCA 3A from another source, typically Lake Okeechobee (USACE 2006a). The L-67 Borrow Canal is specified in the WCA 3A Regulation Schedule, though the WCA 3A floor elevation is traditionally measured at the S-333 headwater gauge; there is no requirement to maintain the L-67A Borrow Canal at or above the WCA 3A floor elevation during water supply deliveries. The SFWMD has indicated that drought year water supply deliveries from Lake Okeechobee can be problematic or extremely difficult if the lake stages are below the level at which pumping, rather than gravity, is needed to pass the water supply releases (typically at a lake stage of approximately 10.5 feet NGVD). If Lake Okeechobee is at levels where water cannot physically be delivered south, then no deliveries will be made from Lake Okeechobee, and no water supply releases from WCA 3A below the floor elevation will be made. If water is available from Lake Okeechobee, then water may be delivered to WCA 3A using one of two routes (both routes may be utilized concurrently, depending on conditions within the system): (1) the western route through the S-3 Structure, along the Miami Canal (within the EAA), and utilizing the S-8 Pump Station into WCA 3A to provide replacement water for the water supply delivery volume that will be delivered to C-6 and/or the SDCS once the replacement water at the north end of WCA 3A is provided; or (2) the eastern route through the S-2 Structure and along the North New River Canal (within the EAA), followed by utilizing either (a) the S-150 gated culvert structure to pass water into WCA 3A (into the L-38W Canal) or (b) utilizing the S-7 Pump Station to release into the L-38E Canal (within WCA 2A) for downstream release through the S-11 structures into WCA 3A (into a more southerly portion of the L-38W Canal than the S-150 outlet). The eastern water supply deliveries route is directly connected to the S-151 structure in the Miami Canal by the L-38W Canal

and the L-68A Borrow Canal, with the L-68 Borrow Canal tying into the L-67A Canal (slightly west of the S-9 Pump Station). These deliveries offset saltwater intrusion into the Biscayne aquifer system.

The most important component of the groundwater system within the study area is the Biscayne aquifer, an unconfined aquifer unit underlying an area of approximately 3,000 square miles in southeast Florida, from southern Palm Beach County southward through Broward County to South Dade County. This huge, freshwater, underground water body is highly productive along the coastal ridge and for a considerable distance to the west. Groundwater in WCA 3 generally flows from the northwest to the southeast, with extensive seepage across the eastern and southern levees, L-30 (southeast corner of WCA 3B) in particular. However, the direction of flow may be influenced by rainfall, drainage canals, or well fields. Fluctuations in groundwater levels are seasonal. Groundwater levels within WCA 3 are influenced by water levels in adjacent canals. 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 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. The permeable limestone of the aquifer is shielded against upward intrusion of saline water from the Floridan aquifer by relatively impermeable beds of clay and marl.

The timing and distribution of water within WCA 3A, WCA 3B, and ENP is affected by direct rainfall, evapotranspiration, and regional water management operations. Specifics relating to the effects of inflows/releases on WCA 3A water level can be found in **Table C.1-2** below.

Table C.1-2. Effects of Inflows/Releases on WCA 3A Water Level

Inflow/Outflow WCA 3A (average daily cfs)	Duration (days)	Effect on WCA 3A (feet)*	Duration (days)	Effect on WCA 3A (feet)*
200	1	0.001	20	0.018
300	1	0.001	20	0.027
400	1	0.002	20	0.036
500	1	0.002	20	0.044
600	1	0.003	20	0.053
700	1	0.003	20	0.062
800	1	0.004	20	0.071
900	1	0.004	20	0.080
1000	1	0.004	20	0.089
1100	1	0.005	20	0.098
1200	1	0.005	20	0.107
1300	1	0.006	20	0.116
1400	1	0.006	20	0.125
1500	1	0.007	20	0.133
1600	1	0.007	20	0.142
1700	1	0.008	20	0.151
1800	1	0.008	20	0.160
1900	1	0.008	20	0.169
2000	1	0.009	20	0.178
2100	1	0.009	20	0.187
2200	1	0.010	20	0.196
2300	1	0.010	20	0.205
2400	1	0.011	20	0.214
2500	1	0.011	20	0.222
2600	1	0.012	20	0.231
2700	1	0.012	20	0.240
2800	1	0.012	20	0.249

Other specific areas within the CEPP project boundaries have distinct hydrologic conditions that could be affected by changes contemplated with CEPP for C&SF infrastructure and/or water management operations. These areas are addressed in the ensuing text.

C.1.1.8.8 Northeast Shark River Slough

NESRS is a complex area located in the northeast corner of ENP. It is currently the northern terminus of SRS, which is aligned from the northeast to southwest across ENP. Tamiami Trail is the northern boundary, the L-31N Canal the eastern boundary, and the L-67 Extension Canal the western boundary of the area. Historically, the area would be characterized as wet most of the year, but regional developments have impacted historic freshwater routes into the area. In addition, if historic levels are not maintained through the end of the wet season, significant reductions in surface water can occur during the dry season below historic dry season levels.

Water enters NESRS primarily from WCA 3A, via S-333, and then to the L-29 borrow canal and subsequent passage through culverts under Tamiami Trail. In addition, pending approval of an operational permit, S-355A and S-355B may also be used to deliver water from WCA 3B to the L-29 Canal for subsequent passage through the culverts to NESRS. The discharges made from WCA 3A

through the S-12 structures and S-333 are target flows determined from the Rainfall Plan (USACE 2006a). Under the Rainfall Plan, water deliveries would be computed and operations adjusted weekly, if necessary based on the sum of two components: a rainfall response component and a WCA 3A regulatory component. The normal operational target flow distribution is 55 percent through the S-333 into NESRS and 45 percent through the S-12 structures into ENP west of the L-67 Extension. Eastern portions of the ENP are also influenced by the system of canals and structures that provide flood control and water supply for the LEC urban and agricultural areas.

C.1.1.8.9 Western Shark River Slough

Western SRS, located to the west of L-67 Extension Levee and bounded on the north by Tamiami Trail, is primarily influenced by rainfall and water management operations at the S-12 structures (A, B, C and D). Under IOP[1], the utilization of the S-12 structures and the seasonal sequential closure periods beginning from the west at S-12A (November 1 – July 15), S-12B (January 1 – July 15), and S-12C (February 1 – July 15), respectively, is meant to move water from WCA 3A into SRS while providing conditions for Cape Sable seaside sparrow Subpopulation-A (CSSS-A) nesting and breeding. Although not required in water management operations, there is a rule-of-thumb that is often utilized that includes delivering the Rainfall Plan S-12 structure target flows from east to west with 40 percent, 30 percent, 20 percent, and 10 percent being discharged at S-12D, S-12C, S-12B, and S-12A, respectively. Releases from WCA 3A are part of a regulation schedule for WCA 3A and are typically dependent on a Rainfall Based Management Plan. This Rainfall Based Management Plan consists of a rainfall-based delivery formula that specifies the amount of water to be delivered to ENP in weekly volumes through the S-333 and S-12 structures. Under IOP, the normal operational target flow distribution is 55 percent through S-333 into NESRS and 45 percent through the S-12 structures into ENP west of the L-67 Extension.

C.1.1.8.10 Taylor Slough

Taylor Slough is in the southeast quadrant of ENP. The area through the Rocky Glades and Taylor Slough is higher in elevation compared to ground levels north, south, or west. Because of this characteristic, the area is normally drier than other areas in the ENP. The Rocky Glades and Taylor Slough are somewhat like an island or a peninsula extending from the canals into the ENP. Under IOP 2006, specified C-111 basin canal water levels/ranges and S-332D pump station operations resulted in Taylor Slough being provided water from C-111 mainly during the wet season. During the dry season, under IOP 2006, water deliveries to Taylor Slough were limited to provide conditions conducive to CSSS nesting (325 cfs from December 1 – January 31; 165 cfs from February 1 – July 15).

C.1.1.8.11 Lower East Coast Area

The LEC area is located to the east of the L-31N, L-31W, and C-111 canals. Under IOP 2006, specified canal water levels/ranges are meant to provide flood protection, water supply, and prevention of saltwater intrusion for the LEC. The LEC can be provided water supply from WCA 3A and Lake Okeechobee according to their respective regulation schedules. In wet conditions, the excess water from the LEC is discharged to tide.

[1] IOP was the governing regulation schedule for the project area at the start of the CEPP planning process. In addition, existing hydrologic conditions within the project area are a result of IOP operations from 2002-2012. ERTP was approved and implemented for operations beginning in October 2012, and ERTP operational assumptions are used in the FWO project analysis.

C.1.1.8.12 8.5 Square Mile Area

The 8.5 Square Mile Area (8.5 SMA) is a primarily residential area adjacent to, but west of, the L-31N Canal. The 8.5 SMA, which is also known as the Las Palmas community, is bordered on both the west and north by NESRS. The community has water management infrastructure consisting of a perimeter levee, a seepage collection canal, a pump station (S-357), and a southern detention cell meant to collectively provide flood mitigation as part of the MWD Project (USACE 2000).

C.1.1.8.13 Biscayne Bay

Biscayne Bay is a shallow, tidal sound located near the extreme southeastern part of Florida. Biscayne Bay, its tributaries, and Card Sound are designated by the State of Florida as aquatic preserves, while Card and Barnes Sounds are part of the Florida Keys National Marine Sanctuary. A significant portion of the central and southern portions of Biscayne Bay comprise Biscayne National Park. Under IOP 2006, specified canal water levels/ranges are meant to provide flood protection for the portions of the LEC and Miami-Dade County, which may result in discharges to Biscayne Bay.

C.1.1.8.14 Florida Bay

Florida Bay and the Ten Thousand Islands comprise approximately 1,500 square miles of ENP. The bay is shallow, with an average depth of less than three feet. To the north is the Florida mainland and to the south lie the Florida Keys. Sheet flow across the marl prairies of the southern Everglades and 20 creek systems fed by Taylor Slough and the C-111 Canal provide direct inflow of freshwater to the bay. Surface water from SRS flows into Whitewater Bay and may also provide essential recharge for central and western Florida Bay. Exchange with Florida Bay occurs when this lower salinity water mass flows around Cape Sable into the western sub-region of the bay.

C.1.1.9 Regional Water Management (Operations)

C.1.1.9.1 Lake Okeechobee

The USACE is responsible for management of the water resources contained within HHD and for the development of regulations for operation of Lake Okeechobee's outlet structures. Water management operations at Lake Okeechobee are performed to ensure that Congressionally-authorized project purposes are met. The Congressionally-authorized project purposes for Lake Okeechobee include: flood control; navigation; water supply for ENP, salinity control, regional groundwater control, agricultural irrigation, municipalities and industry; enhancement of fish and wildlife; and recreation. Since April 2008, Lake Okeechobee has been operated in accordance with the 2008 Lake Okeechobee Regulation Schedule (2008 LORS; refer to **Figure C.1-3** through **Figure C.1-7**); for additional details and complete documentation, refer to the USACE November 2007 Lake Okeechobee Final Supplemental EIS. Changes to the Lake Okeechobee Regulation Schedule with the 2008 LORS are included in the revised March 2008 USACE Lake Okeechobee and Everglades Agricultural Area Water Control Plan (WCP). The WCP, which codifies the water management operational guidance included in the November 2007 Final Supplemental EIS, defines allowable releases to the Water Conservation Areas (WCAs) and to tide (estuaries). Prior to the 2008 LORS, Lake Okeechobee operations were managed under the "Water Supply and Environment (WSE) Regulation Schedule" since July 2000.

The regulation schedule is a tool used by water managers to meet Congressionally-authorized project purposes. A regulation schedule attempts to meet all functional objectives of the particular project, acting separately or in combination with other projects in a system. The regulation schedule has been, and will continue to be, designed to balance multiple, and often competing,

project purposes and objectives. Managing for better performance of one objective often lessens the effectiveness of performance of competing objectives. For example, higher regulation schedules tend to benefit water supply, but may increase the risk to public health and safety, and can harm the ecology of the lake. Lower lake schedules may produce lake levels more desirable for the lake ecology and improved flood protection, but reduce water supply potential. Lower lake schedules may also harm the ecology of the lake during extended dry periods and downstream estuaries during extended wet periods. Therefore, the 2008 LORS was not developed to optimize performance of any single project purpose, but rather balances the performance of the multiple project purposes. The regulation schedule contains bands which vary with the time of year. Releases are outlined by flowcharts that define the allowable releases by structure within each band.

Though water supply is a project purpose, water supply release volumes are not prescribed by this regulation schedule. However, water supply releases are made to meet downstream demands that can include agricultural irrigation, municipal and industrial needs, estuary, and other environmental water supply needs.

The 2008 LORS operational study was initiated to address high lake levels, high estuarine discharges, estuary ecosystem conditions, and lake ecology conditions that occurred during the 2003 to 2005 time period. The study considered the back-to-back historically significant 2004 and 2005 hurricane seasons' effects on the recognized structural integrity issues of HHD along with effects to other project purposes. The 2008 LORS was identified to be effective at decreasing the risk to public health and safety, reducing the number of high-volume discharges to the estuaries, and providing critical flexibility to perform water management operations (November 2007 Final Supplemental EIS).

Under the 2008 LORS, management of Lake Okeechobee water levels and determination of Lake Okeechobee releases to the WCAs and to tide (estuaries) is based on seasonally varying lake elevations divided into three bands as shown on the proposed 2007 Lake Okeechobee Interim Regulation Schedule Part A. These bands include "High Lake Management", "Operational", and "Water Shortage Management". The High Lake Management Band is meant to address public health and safety, especially related to the structural integrity of HHD by providing the ability to make releases up to the maximum capacity lake outlets will allow; Lake Okeechobee outlet canals may be maintained above their optimum water management elevations. The Operational Band is meant to facilitate authorized project purposes by providing the ability to make releases of various volumes, including no release; Lake Okeechobee outlet canals should be maintained within their optimum water management elevations. The Water Shortage Management Band pertains to low lake levels which necessitate rationing water supplies; Lake Okeechobee outlet canals may be maintained below their optimum water management elevations. The water supply releases made within this band are made according to the SFWMD's Lake Okeechobee Water Shortage Management Plan (LOWSM). The 2008 Lake Okeechobee Interim Regulation Schedule Part B further defines the bands of the regulation schedule. In Part B, the Operational Band is further subdivided into sub-bands that are directly related to defining allowable Lake Okeechobee releases to the WCAs and to tide (estuaries). In general as lake levels rise through the higher sub-bands, the allowable release rates increase.

The 2008 LORS EIS analysis demonstrated that the then-proposed regulation schedule releases to the WCAs and to the estuaries would reduce the likelihood of lake levels that both increase the

probability of a breach of the HHD and also contribute to poor ecological conditions within Lake Okeechobee. For Lake Okeechobee, a high lake level can lead to the decline of emergent and submerged vegetation which is essential habitat for the lake's fish and wildlife populations. The 2008 LORS provides the ability to make long-term, low-volume releases to the Caloosahatchee Estuary, St. Lucie Estuary, and WCAs. These releases include low-volume pulse releases and base flow releases to the Caloosahatchee and St. Lucie estuaries that allow Lake Okeechobee to be maintained at more desirable levels throughout the year. A pulse release attempts to simulate a natural rainstorm event within the basins. The receiving body would respond to the pulse release in a similar fashion as if a rainstorm had occurred in the upstream watershed. Although an average flow rate is targeted for the duration of the pulse release, daily releases vary. The pulse releases and base flow releases are intended to regulate lake levels and reduce the potential for future prolonged high-volume releases to the estuaries. The base flow releases also provide a benefit of maintaining desirable salinity levels in the estuaries. By regulating lake levels, these low volume releases improve public health and safety performance by reducing risk to the HHD and provide improved benefits for the health of Lake Okeechobee and the estuaries.

C.1.1.9.2 Greater Everglades

The C&SF Project has numerous water management structures consisting of culverts, spillways, and pump stations that have specified operating criteria for managing or regulating water levels for Congressionally-authorized project purposes. The C&SF Project contains multiple water bodies created by the existing C&SF levee infrastructure and implementation of the water management operating criteria, including WCA 1, WCA 2, and WCA 3. Associated with the inflow to and discharge from the water bodies is an infrastructure of structures and canals that are managed by the implementation of water management operating criteria that can include specified water levels or ranges. The WCA 3A Interim Regulation Schedule is a compilation of water management operating criteria, guidelines, rule curves, and specifications that govern storage and release functions. Typically, a regulation schedule has water level thresholds which vary with the time of year and result in discharges. The threshold lines of regulation schedules define the discharge zones and are traditionally displayed graphically. Additionally, a corresponding table is typically used to identify the structure discharge rules for the zones. As with most regulation schedules, the WCA 1, WCA 2, and WCA 3A regulation schedules must take into account various, and often conflicting, project purposes.

The WCAs are regulated for the Congressionally-authorized C&SF Project purposes to provide: flood control; water supply for agricultural irrigation, municipalities and industry, and ENP; regional groundwater control and prevention of saltwater intrusion; enhancement of fish and wildlife; and recreation. An important component of flood control is the maintenance of marsh vegetation in the WCAs, which provide a dampening effect on hurricane-induced wind tides that have the potential to affect residential areas to the east of the WCAs. The marsh vegetation, along with the east coast protection levee, also prevents floodwaters that historically flowed eastward from the Everglades from flowing into the developed areas along the southeast coast of Florida. Modifications to the WCA 1 and WCA 2 Regulation Schedules are not under consideration with the CEPP, and the following description of existing water management operations will only include WCA 3A, WCA 3B, and ENP.

Besides releases from WCA 2A via the S-11 structures, WCA 3A receives inflow from pumping stations S-8, S-9, and S-140. The S-9 pump station removes runoff in the area west of Ft. Lauderdale known as Western C-11. The S-9A pump station, located adjacent to the S-9 pump station, returns

seepage water from WCA 3A and WCA-3B collected in the L-37, L-33 and the US 27 borrow canals. The S-140 pump station serves the 110 square mile area north and east of the interceptor canal and west of L-28. This station is used to maintain canal levels below 10.5 feet, NGVD unless gravity flow into WCA 3A is possible at an adequate rate. Water also enters northeastern WCA 3A by gravity through S-150. Discharges at S-142 are made from WCA 3A into the North New River Canal. The SFWMD can pump runoff from the North New River Canal and C-13 into WCA 3A through S-142 by operating their pump station, G-123.

Water levels in WCA 3A are managed primarily by five gated spillways: the S-12 structures (S-12A, S-12B, S-12C, and S-12D) and S-333. Additionally, S-151, S-343A, S-343B and S-344 can also be utilized to discharge from WCA 3A. The S-12 structures and S-333 are utilized to provide water deliveries to ENP, in accordance with the WCA 3A Regulation Schedule. From July 2002 through October 2012, WCA 3A was regulated according to a seasonally varying 8.75 to 10.75 feet, NGVD regulation schedule and the Rainfall Plan (initiated in 1985), as per IOP (2006 IOP Supplemental Environmental Impact Statement [EIS]; refer to Figure C.1-8). The CEPP ECB assumptions represent the system-wide infrastructure and operations that were in place at the time CEPP plan formulation was initiated, approximately January 2012. The primary objective in implementing IOP was to reduce damaging high water levels within CSSS habitat west of SRS (i.e. CSSS-A). IOP was designed to protect the CSSS to the maximum extent possible through water management operations. The purpose of IOP was to provide an improved opportunity for CSSS nesting by maintaining water levels below ground level for a minimum of 60 consecutive days between March 1 and July 15, corresponding to the CSSS breeding season. In addition, a secondary purpose of IOP was to allow CSSS habitat to recover from prolonged flooding during the mid-1990s. The IOP WCA 3A Interim Regulation Schedule utilizes a 3-gauge average elevation of Sites 63, 64, and 65 in the management of WCA 3A water levels (also known as 3A-3, 3A-4 and 3A-28, respectively). The discharges made from WCA 3A through the S-12 structures and S-333 are target flows determined from the Rainfall Plan; when WCA 3A is in Zone A, these target flows are the maximum flow possible. Under the Rainfall Plan, water deliveries are computed and operations adjusted, weekly, if necessary based on the sum of two components: a rainfall response component and a WCA 3A regulatory component. The Rainfall Plan provides for the rainfall response component within all zones of the WCA 3A Regulation Schedule, with the additional regulatory release requirement added when the WCA 3A water levels fall within the higher regulation schedule zones above Zone E, including Zone E1. Under IOP, the goal of the rainfall and regulatory components is to split the flows between the S-12 structures and S-333, with 45 percent of the total flow from WCA 3A passing through the S-12 structures to Western SRS and the remaining 55 percent to discharge through S-333 to NESRS, establishing the target flows for both the S-12 structures and S-333. IOP specifies seasonal closure of the S-12 structures, with the following rigid closure periods: November 1 – July 15 for S-12A; January 1 – July 15 for S-12B; and February 1 – July 15 for S-12C.

Water deliveries to eastern ENP are controlled by the stage in L-29 Canal, as pressure from the water within the canal (hydraulic head), is required to force water through the Tamiami Trail culverts and into ENP. As canal stage increases, more water is forced beneath the road through 19 sets of culverts (55 total culverts, three culverts per set in most locations). The L-29 Canal stage is currently limited due to concerns regarding potential flooding and seepage effects within residential or agricultural areas of Miami-Dade County and potential damage to the Tamiami Trail roadway sub-base. The water management operating criteria for the L-29 borrow canal between S-333 and S-334 is meant to limit the L-29 borrow canal stage to no more than 7.5 feet NGVD in response to roadway sub-base concerns identified by the Florida Department of Transportation (FDOT), although short-

term deviations have been previously implemented in response to specific hydrologic conditions. Higher water levels within the canal may erode the roadway sub-base and create a potential safety hazard, until completion of the Modified Water Deliveries (MWD) Tamiami Trail Modifications project in 2013. In addition, the L-29 borrow canal water level has an additional constraint related to potential flooding and seepage effects within residential and/or agricultural areas of Miami-Dade County. When the G-3273 water level within NESRS reaches 6.8 feet NGVD, S-333 discharges to NESRS will be discontinued until G-3273 falls below 6.8 feet NGVD. Tamiami Trail roadway modifications, to accommodate potential maximum L-29 borrow canal water levels up to 8.5 feet NGVD are currently in progress with the ongoing MWD project. Additionally, a one-year field test to incrementally relax the G-3273 operational constraint is under consideration for 2013-2014.

When WCA 3A water levels are in Zone A of the WCA 3A Regulation Schedule (USACE 2006a), S-343A, S-343B, and S-344 can be utilized to discharge from WCA 3A into BCNP. Discharges can also be made through S-343A, S-343B and S-344 when agreed to by SFWMD, USACE, and National Park Service (NPS) to extend hydroperiods within BCNP. The S-151 gated culvert structure, which is located along the Miami Canal and operated according to the WCA 3A Regulation Schedule (USACE 2006a), is the only existing surface water connection between WCA 3A and WCA 3B. S-151 discharges into C-304 in WCA 3B for flood diversion and for the purpose of providing water supply to LEC canals and the ENP SDCS. Under existing conditions, water does not flow directly from WCA 3B into the L-29 Canal. There are two discharge structures, S-355A and S-355B, along L-29 south of WCA 3B that are designed to move water from WCA 3B into the canal, although the operation of these structures has not been previously authorized for more than short-term, temporary operations. The S-355 structures are completed components of the MWD Project, intended to function in concert with the proposed MWD S-345 structures along L-67A/L-67C to address the MWD Project objective of restoring WCA 3B as a functioning component of the Everglades hydrologic system and restoration of water deliveries to NESRS.

There are three distinct modes of water management operations for IOP: Column 1, Column 2, and water supply (USACE 2006a). Water management operating criteria within Column 1 occurs when WCA 3A discharges can be achieved by discharges from the S-12 structures, S-333, S-151, S-343A, S-343B, and/or S-344. Water management operating criteria within Column 2 occurs when WCA 3A discharges are made via S-333 to the L-29 Canal and L-31N Canal, and the ENP SDCS; Column 2 generally requires the use of pump stations S-331, S-332B, S-332C, and S-332D. Column 2 is used to offset or mitigate for adverse effects on WCA 3A related to closure periods at water management structures to protect CSSS-A. Column 2 generally occurs when any S-12 structure is closed in order to protect the CSSS (November 1 through July 15, under IOP), although Column 1 may continue until the capacity of the S-12 structures that remain open is insufficient to handle the discharge from WCA 3A. If necessary, Column 2 may continue past re-opening of the S-12 structures (July 16) to mitigate for adverse effects on WCA 3A resulting from the IOP closures of S-12A, S-12B, S-12C, S-343A, S-343B, and S-344. Water supply discharges from WCA 3A occur when water levels in the ENP SDCS fall to a level that indicates additional water is required. During droughts, a minimum elevation in the borrow canals of 7.5 feet NGVD is established in the WCA 3A Interim Regulation Schedule (USACE 2006a). Below this elevation no further releases will be permitted from WCA 3A unless an equal supply of water from another storage area is transferred to WCA 3A.

Additional information on the effects of water management within the Greater Everglades environment may be found within the South Florida Environmental Reports which are published annually by the SFWMD:

(http://my.sfwmd.gov/portal/page/portal/xweb%20about%20us/agency%20reports#previous_reports).

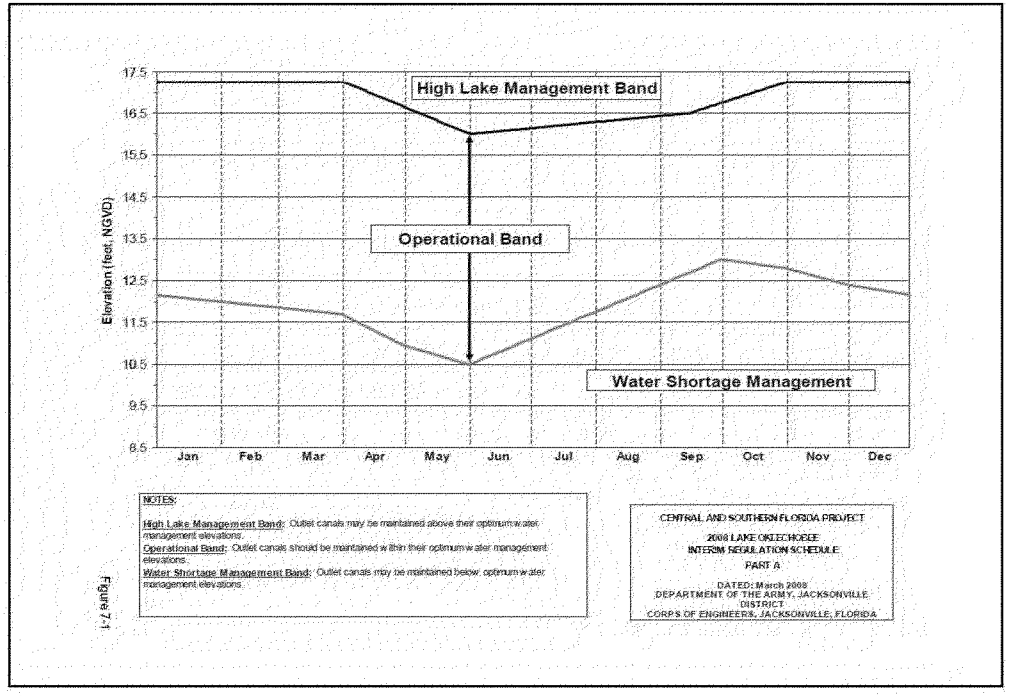


Figure C.1-3. 2008 Lake Okeechobee Regulation Schedule Part A

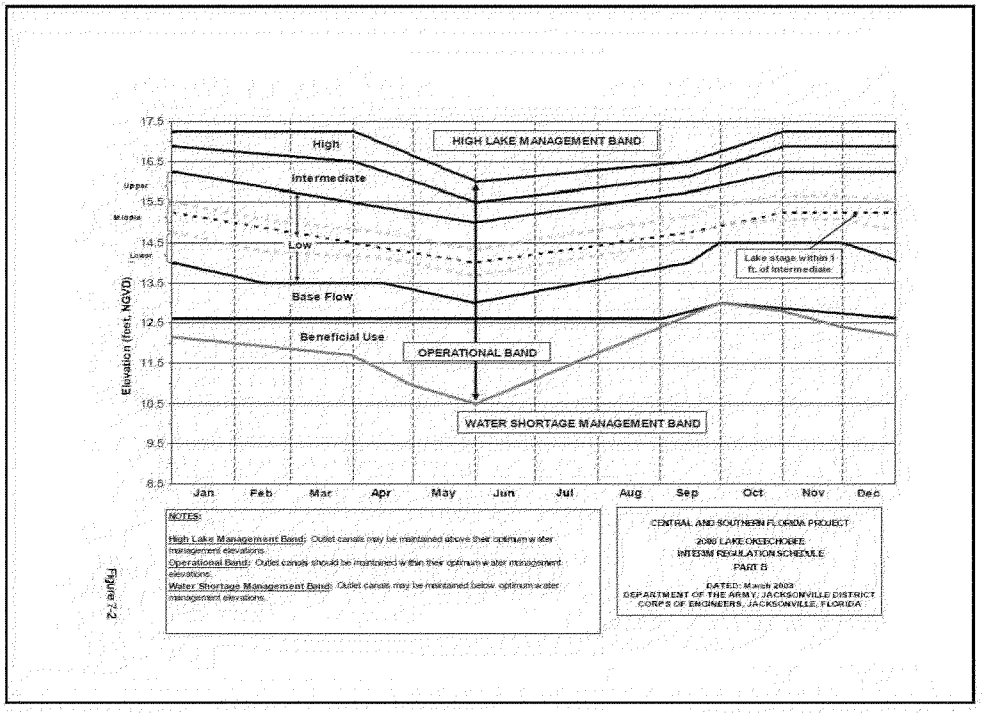


Figure 7-2

Figure C.1-4. 2008 Lake Okeechobee Regulation Schedule Part B

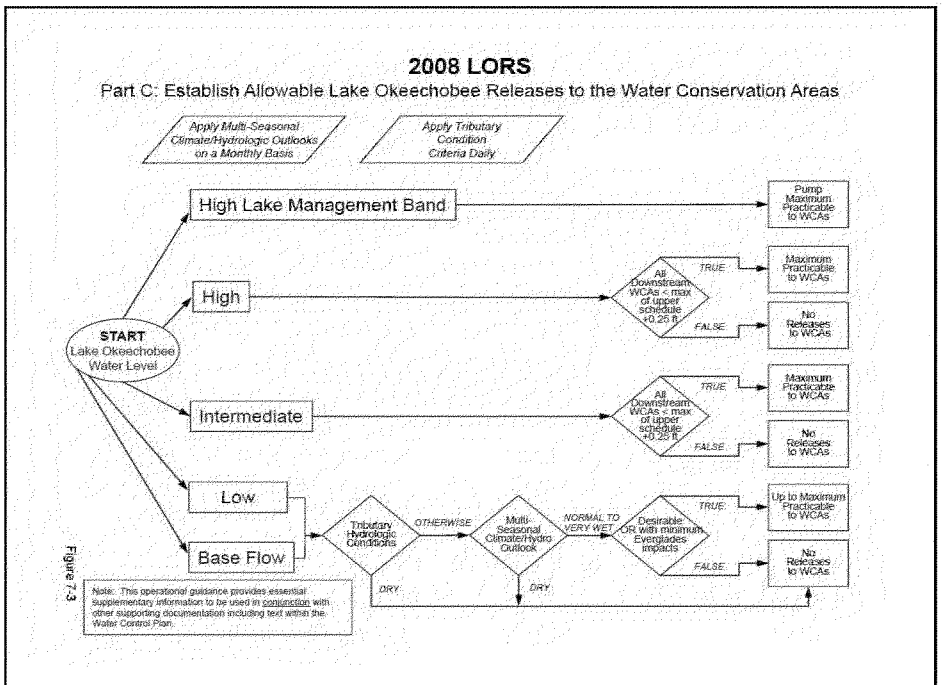


Figure 7-3

Figure C.1-5. 2008 Lake Okeechobee Regulation Schedule Part C

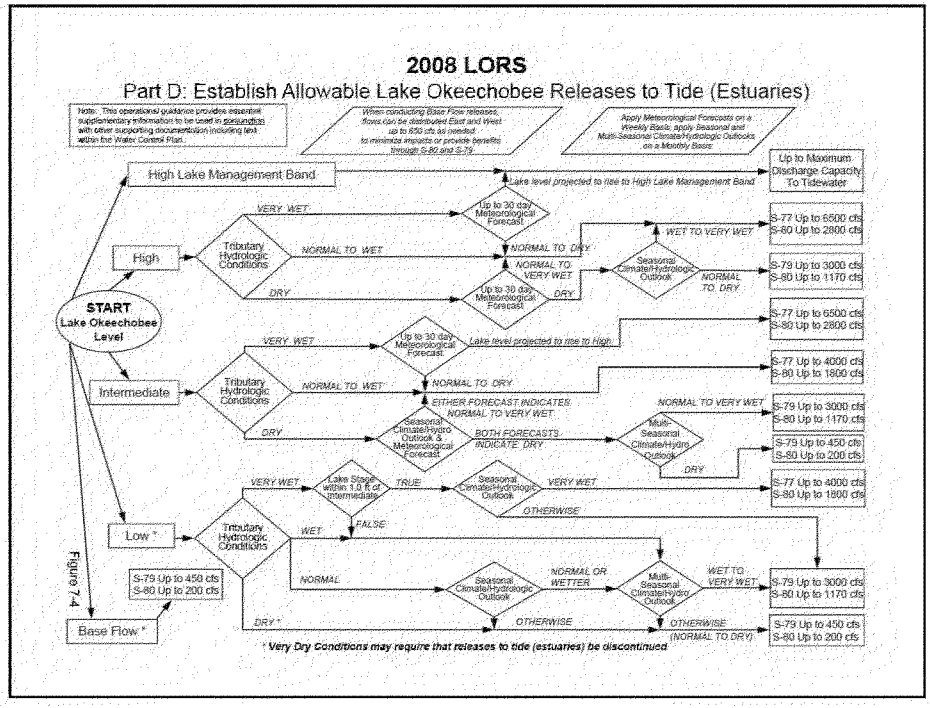
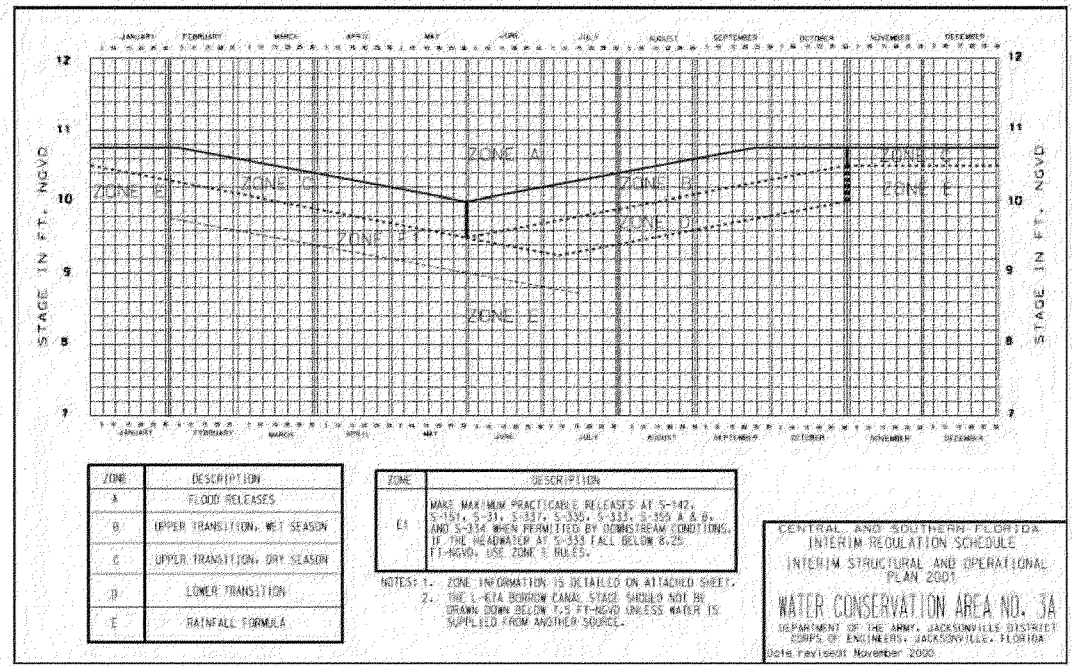


Figure C.1-6. 2008 Lake Okeechobee Regulation Schedule Part D



Note: Figure 9 from 2002 IOP Final SEIS.

Figure C.1-7. IOP Water Conservation Area 3A Interim Regulation Schedule Part A

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C.1.1.10 Flood Control

Water management and flood control is achieved in south Florida through a variety of canals, levees, pumping stations, and control structures within the WCAs, ENP, and SDCS. The WCAs provide a detention reservoir for excess water from the EAA and parts of the east coast region, and for flood discharge from Lake Okeechobee to tide. The WCAs provide levees to prevent the Everglades floodwaters from inundating the east coast urban areas; provide a water supply for the east coast areas and ENP; improve water supply for east coast communities by recharging underground freshwater reservoirs; reduce seepage; ameliorate salt-water intrusion in coastal well fields; and provide mixed quality habitat for fish and wildlife in the Everglades.

The regulation schedules for the WCAs contain instructions and guidance on how project spillways are to be operated to maintain water levels in the WCAs. The regulation schedules represent the seasonal and monthly limits of storage which guides project regulation for the authorized purposes. In general, the schedules vary from high stages in the late fall and winter to low stages at the beginning of the wet season. These regulation schedules must take into account various, and often conflicting, project purposes.

The East Coast Canals are flood control and outlet works that extend from St. Lucie County southward through Martin, Palm Beach, and Broward Counties to Dade County. The East Coast Canal watersheds encompass the primary canals and water control structures located along the LEC and their hydrologic basins. The main design functions of the project canals and structures in the East Coast Canal area are to protect the adjacent coastal areas against flooding; store water in conservation areas west of the levees; control water elevations in adjacent areas; prevent salt-water intrusion and over-drainage; provide freshwater to Biscayne Bay; and provide for water conservation and public consumption. The East Coast Canals consist of 40 independently operated canals, one levee, and 50 operating structures, consisting of 35 spillways, 14 culverts, and one pump station. The project operates to prevent major flood damage; however, due to urbanization, the existing surface water management system now has to handle greater peak flows than in the past. The ENP SDCS provides a way to deliver water to areas of south Dade County. This canal system was overlaid on the existing flood control system. Many of these canals are used to remove water from interior areas to tide in times of excess water.

C.1.1.11 Water Supply

C.1.1.11.1 Lake Okeechobee

As one of the federally authorized project purposes, Lake Okeechobee supplies water for agricultural irrigation, municipalities, industry, and ENP, and for regional groundwater and salinity control. The primary water supply uses of Lake Okeechobee are to provide water supply for adjacent agricultural lands and to serve as a backup water supply for the Lower East Coast Service Area (LECSA) and west coast Florida counties when rainfall is insufficient and during dry periods (**Figure C.1-8**).

Lake Okeechobee and its connected conveyance system are the most significant surface water sources for the Lake Okeechobee Service Area (LOSA), which includes the EAA (**Figure C.1-8**). Surface water from the lake and runoff from the EAA supply water to the regional system via canals and provide recharge to the Surficial Aquifer System. Agriculture in the LOSA covered approximately 255,500 acres outside of the EAA and the 460,000 acres within EAA in 2010 (most recent data available) and is the predominate user of lake water. Agricultural water supply demands equate to approximately 480,000 acre-feet per year for LOSA, which includes 303,000 acre-feet per year for just the EAA.

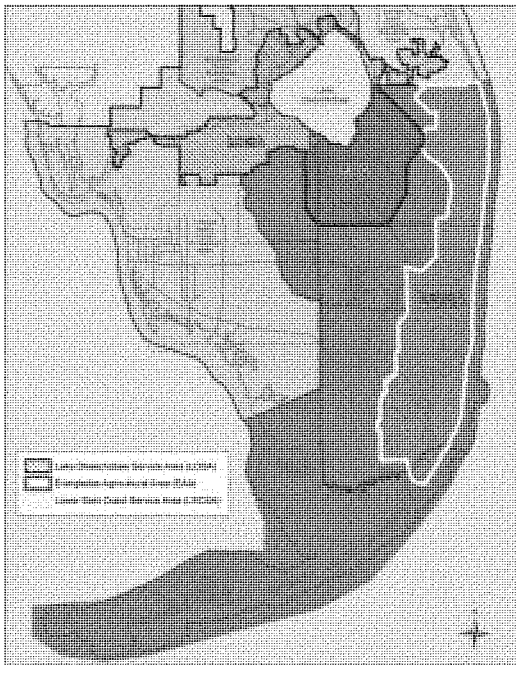


Figure C.1-8. Map of Lake Okeechobee Service Area, Everglades Agricultural Area and Lower East Coast Service Area

In 2008, the USACE implemented the 2008 Lake Okeechobee Regulation Schedule (2008 LORS). The 2008 LORS provides operational flexibility to make Lake Okeechobee releases to meet project purposes as specified in the Water Control Plan. SFWMD also provides recommendations for USACE consideration regarding releases to the Everglades or the Northern Estuaries for Lake Okeechobee regulatory releases within the low, base-flow or beneficial use sub-bands of the 2008 LORS schedule.

The right to use water within the CEPP project area is authorized by a permit issued by the SFWMD. The conditions of permit issuance are more specifically enumerated in Chapters 40E-2 and 40E-20 of the Florida Administrative Code (F.A.C.), which also incorporate by reference the current SFWMD Basis of Review for Water Use Permit Applications (SFWMD 2012a). In order to provide reasonable assurances that the conditions of permit issuance are met, applicants must meet consumptive use permitting criteria. The technical criteria used to evaluate the purpose, quantity, and source of proposed water to be used include the following: (1) saltwater intrusion, (2) wetland and other surface water body impacts, (3) pollution, (4) impacts to off-site land uses, (5) interference with existing legal users, and (6) minimum flows and levels.

Water supplies allocated from Lake Okeechobee and its connected conveyance systems are primarily for supplemental irrigation to the LOSA agricultural areas. In the LOSA, the Okeechobee Utility Authority is the only remaining Public Water Supply (PWS) utility using water directly from Lake Okeechobee.

Clewiston, South Bay, Belle Glade, and Pahokee have discontinued the use of Lake Okeechobee as their supply source and now use Floridan aquifer water treated by reverse osmosis for all of their PWS demand since 2005.

Water shortages are declared by the SFWMD Governing Board when available groundwater or surface water is not sufficient to meet users' needs or when conditions require temporary reduction in total use within the area to protect water resources from serious harm. The SFWMD's Water Shortage Plans are contained in Chapters 40E-21 and 40E-22, F.A.C. The purposes of the plans are to protect the water resources of the SFWMD from serious harm; assure equitable distribution of available water resources among all water users during times of shortage, consistent with the goals of minimizing adverse economic, social, and health related impacts; provide advance knowledge of the means by which water apportionments and reductions will be made during times of shortage; and promote greater security for consumptive use permittees. The current SFWMD water shortage management plan for Lake Okeechobee, known as the Lake Okeechobee Water Shortage Management (LOWSM) Plan (implemented in November 2007), requires various actions to be taken according to the severity of the actual and projected lake water levels. The basis of this plan is an allocation scheme that parcels out lake water based on a percentage of the 1-in-10 water demand. If the lake level continues to fall, the percentage of water restrictions increases. If the water level at the beginning of the dry season is low, then the likelihood of water restrictions is greater.

In October 2008, the SFWMD adopted Restricted Allocation Area criteria for the Lake Okeechobee Service Area as part of the Minimum Flow and Level (MFL) recovery strategy for Lake Okeechobee following an extended drought and USACE implementation of the 2008 LORS, which generally lowered the water levels in Lake Okeechobee. According to the SFWMD, without modification to the current LOWSM, the frequency of water shortage restrictions is expected to increase from 1-in-10 years to experiencing restrictions 1-in-6 years while the lake is being operated under the 2008 LORS. As a result of the potential impacts to water supply, the SFWMD enacted rules to limit future additional withdrawals from Lake Okeechobee in order to prevent further degradation of the level of certainty for existing legal users and to avoid exceeding the MFL criteria. The SFWMD rules also ensures that water necessary for Everglades restoration is not allocated for consumptive use. The regulatory criteria limit allocations from Lake Okeechobee and connected surface waters, including the Caloosahatchee River and St. Lucie River, to base condition water uses as defined within the SFWMD Basis of Review for Water Use Permit Applications for the period from April 1, 2001 to January 1, 2008 (SFWMD 2012a).

C.1.1.11.2 Seminole Tribe of Florida

The Seminole Tribe of Florida has six reservations located in Florida. The reservations include Brighton, Tampa, Fort Pierce, Immokalee, Hollywood, and Big Cypress. Hollywood is the headquarters location for the Seminole Tribe of Florida.

Two reservations of the Seminole Tribe of Florida rely on Lake Okeechobee as a secondary supplemental irrigation supply source for their surface water, with specific volumes of water identified for this purpose for the Seminole Tribe of Florida's Big Cypress Reservation and an operational plan addressing drought-water shortage operations for the Brighton Reservation.

The Seminole Tribe of Florida has surface water entitlement rights pursuant to the 1987 Water Rights Compact between the Seminole Tribe of Florida, the State of Florida, and the SFWMD. (Public Law No. 100-228, 101 Stat. 1566 and Chapter 87-292 Laws of Florida as codified in section 285.165, Florida Statutes). Additional documents addressing the Water Rights Compact entitlement provisions have since

been executed. These documents include Agreements between the Tribe and SFWMD and a SFWMD Final Order. Of particular interest in this regard is the 1996 Agreement which commits the SFWMD to mitigate impacts to the Tribe's ability to obtain surface water supplies at both the Brighton and Big Cypress Reservations, which may be diminished as a result of various activities.

For the Big Cypress Reservation, SFWMD has installed forward pumps to deliver water from Lake Okeechobee at lower stages to the Miami Canal. This option remains a part of drought management alternatives. Also, real-time operational decisions made during a declared drought event include recognition of the Tribe's water rights. These decisions remain a part of the SFWMD drought management operations.

For the Brighton Reservation, various options of securing both short and long-term water supply deliveries to agricultural operations in the Southern Indian Prairie Basin are being evaluated extensively and implemented where possible. For example, other water source and conveyance options, including deviations to the Lake Istokpoga Regulation Schedule (USACE 1994) to provide for additional water supply and modifications to the C-40 canal to augment the pump station G-208 capability, continue to be explored. Preliminary discussions remain ongoing with the USACE and the USFWS in respect to deviations of the Lake Istokpoga Regulation Schedule.

C.1.1.11.3 Lower East Coast Service Areas

Fresh groundwater is the primary source of supply for potable water consumption, landscape irrigation, and industrial and commercial uses in the LECSA. The LECSA includes Northern Palm Beach County, LECSA 1 (Palm Beach), LECSA 2 (Broward County/Fort Lauderdale), and LECSA 3 (Miami-Dade) (**Figure C.1-9**). Irrigated agricultural acreage for the LECSA is shown in **Table C.1-3.** In the urban areas, PWS relies heavily on the Surficial Aquifer System (SAS), including the Biscayne aquifer. The SAS produces good quality, fresh water from relatively shallow wells. In many cases, the ambient water quality meets primary and secondary drinking water quality standards. These aquifers are recharged by local rainfall, groundwater seepage from the WCAs and Everglades National Park, and surface water deliveries from the WCAs. When sufficient water is available, surface water from Lake Okeechobee can also be routed to the WCAs, then to regional canals to maintain water levels and recharge the aquifer.

Table C.1-3. Irrigated Agricultural Acreage for LECSA (Source 2013 LECSA Draft Water Supply Plan)

Category	Acreage			
	Broward	Miami-Dade	Palm Beach	Total
Irrigated Lands				
Urban Irrigated	128,167	151,362	122,506	**403,282**
Transportation, Communication, & Utilities	3,136	7,039	2,937	**13,112**
Golf Course	7,113	3,720	13,776	**24,767**
Mixed Crops	0	23	0	**23**
Row Crops	819	28,000	10,920	**40,673**
Field Crops	40	1,974	0	**2,014**
Sugar Cane	0	0	1,104	**1,143**
Citrus	2	717	2,464	**5,165**
Other Fruit & Nuts	80	8,000	102	**8,182**
Greenhouse/Nursery	250	9,000	3,798	**13,187**
Sod	9	114	1,953	**2,076**
Specialty Farms	442	216	5,758	**6,423**
Cattle Feeding Operations	0	0	0	**51**
Irrigated Lands Total	**140,058**	**210,165**	**165,318**	**520,098**
Wastewater Reuse				
Urban	1,491	0	4,500	**5,999**
Golf Course	1,047	0	6,506	**8,002**
Transportation, Communication, & Utilities	29	0	61	91
Wastewater Reuse Total	**2,568**	0	**11,067**	**14,092**
Floridan Aquifer				
Golf Course	0	0	335	**335**
Floridan Aquifer Total	**0**	**0**	**335**	**335**
Non-Irrigated Lands				
Urban Non-Irrigated	57,990	59,437	90,873	**208,932**
Urban Under Construction	3,000	3,259	5,731	**12,258**
Transportation, Communication, & Utilities	17,953	21,526	14,758	**54,566**
Pasture	1,585	1,178	5,255	**9,239**
Abandoned Groves	460	96	2,193	**2,907**
Fallow Crop Land	1,585	12,219	7,195	**21,490**
Upland Non-Forested	1,286	3,458	7,198	**14,035**
Upland Forested	3,775	4,376	50,055	**65,779**
Open Water	31,120	34,480	38,537	**106,243**
Wetlands	25,479	120,168	102,601	**254,966**
Barren Land	738	4,053	2,701	**7,494**
Non-Irrigated Lands Total	**144,971**	**264,251**	**327,097**	**757,910**
Grand Total	**287,597**	**474,415**	**503,816**	**1,292,434**

During the wet season, well fields are recharged by local rainfall and by the regional system that provides continuous seepage from the WCAs to the regional aquifer and the canals. During the wet season, "excess" storm water is also passed through the canals and out to tide due to the limited storage capability within the LEC coastal canal system. Without sufficient storage, it has been difficult to have water available during the dry season without causing flooding during the wet season. Another concern is that, at present, the flow of water along the eastern protective levee is from the Everglades' wetlands to the coast; keeping the water levels high west of the Atlantic Coastal Ridge, and managing levels low to the east of it, results in large groundwater losses from the remnant Everglades throughout the year. This situation has reduced the coastal groundwater flows into estuaries like Biscayne Bay and has made it necessary to import regional water to the Lower East Coast to maintain adequate coastal groundwater levels to prevent saltwater intrusion.

The pattern described above occurs during wet seasons and during normal rainfall years. During extremely dry years, no water reaches the coast and the urban well fields depend heavily on deliveries from the WCAs (including the ongoing seepage from these areas) and Lake Okeechobee via the primary canals for water supplies. During droughts, lower regional groundwater levels may cause inland movement of saline water at the interface of the aquifer with seawater. Minimum stages are maintained in LEC canals principally to protect the Biscayne Aquifer from saltwater intrusion, a major threat to this water resource. Maintaining canal stages during dry conditions serves to raise local and regional groundwater levels to recharge the aquifer, which, in turn, supplies the urban well fields. Even during normal dry seasons when flood releases are minimal, the high demands on the system from urban water supply may be withdrawing water from the natural environment that could alternatively be kept in the system for late winter and spring biological rejuvenation. In addition, during drought years, the urban and agricultural areas create additional demands on the regional water supply as the need for irrigation increases, with a significant percentage of this irrigation water consumed for landscape maintenance (sourced primarily from shallow wells and surface waters). Under drought conditions, water shortage restrictions within the LEC Service Areas may be declared by the SFWMD Governing Board to conserve freshwater supplies.

Due to efficiency in application, the amount of water needed to recharge urban well fields is small compared to the tremendous volumes needed to prevent saltwater intrusion. Preventing saltwater intrusion is important to maintain the long-term viability of the primary ground water supply for the LECSA. For example, if significant saltwater intrusion occurred even once, the easternmost well fields would be contaminated indefinitely and would be replaced with wells further west. This situation has already occurred in eastern Miami-Dade County, and Broward and Palm Beach Counties.

Figure C.1-10 shows the distribution of SFWMD-permitted SAS wells for PWS utilities producing over 0.1 million gallons per day (MGD). The map reveals that well capacities generally increase from Palm Beach County to the south towards Miami-Dade County as a result of the presence of the Biscayne aquifer within SAS. The transmissivity of the Biscayne aquifer increases from north to south. In 2010 (latest information available), PWS utilities utilized 788 MGD of fresh groundwater to supply 94 percent of their total potable water demand. In addition to PWS, agriculture in Broward and Miami-Dade Counties is primarily dependent upon withdrawals from the Biscayne aquifer to supply supplemental irrigation for crops, livestock, and other purposes.

The SAS, including the Biscayne aquifer, is a source of limited availability to the extent that withdrawals result in induced seepage from the C&SF Project, except when stormwater discharge or wet season discharge occurs, as defined by Section 1.7.2.2.B of the Basis of Review for Water Use Permit

Applications within the South Florida Water Management District, commonly referred as the SFWMD Basis of Review (2012a). The SFWMD adopted the Everglades and Loxahatchee River Watershed Restricted Allocation Area criteria (Section 3.2.1.E, Basis of Review) in 2007. If a utility pursues increased withdrawals from the SAS, this source is generally limited due to potential impacts on wetlands and existing legal water users including Domestic Self-Supply and the potential for saltwater intrusion. New or increased allocations are evaluated by the SFWMD on an application-by-application basis to determine if the project meets consumptive use permitting criteria.

In addition to the regulatory limitation on water availability, there is also physical limit of water available due to regulation schedules for the WCA's. Water supply deliveries from the WCAs to coastal canals are utilized to maintain coastal canals and to recharge coastal well fields during dry hydrologic conditions. When canal levels drop below adequate recharge levels due to a combination of wellfield drawdowns, evaporation, and lack of rainfall, water supply deliveries are typically made from the regional C&SF system. When canal levels drop in Miami-Dade County, regional water supply is delivered from WCA 3A through one of two delivery routes, as previously described.

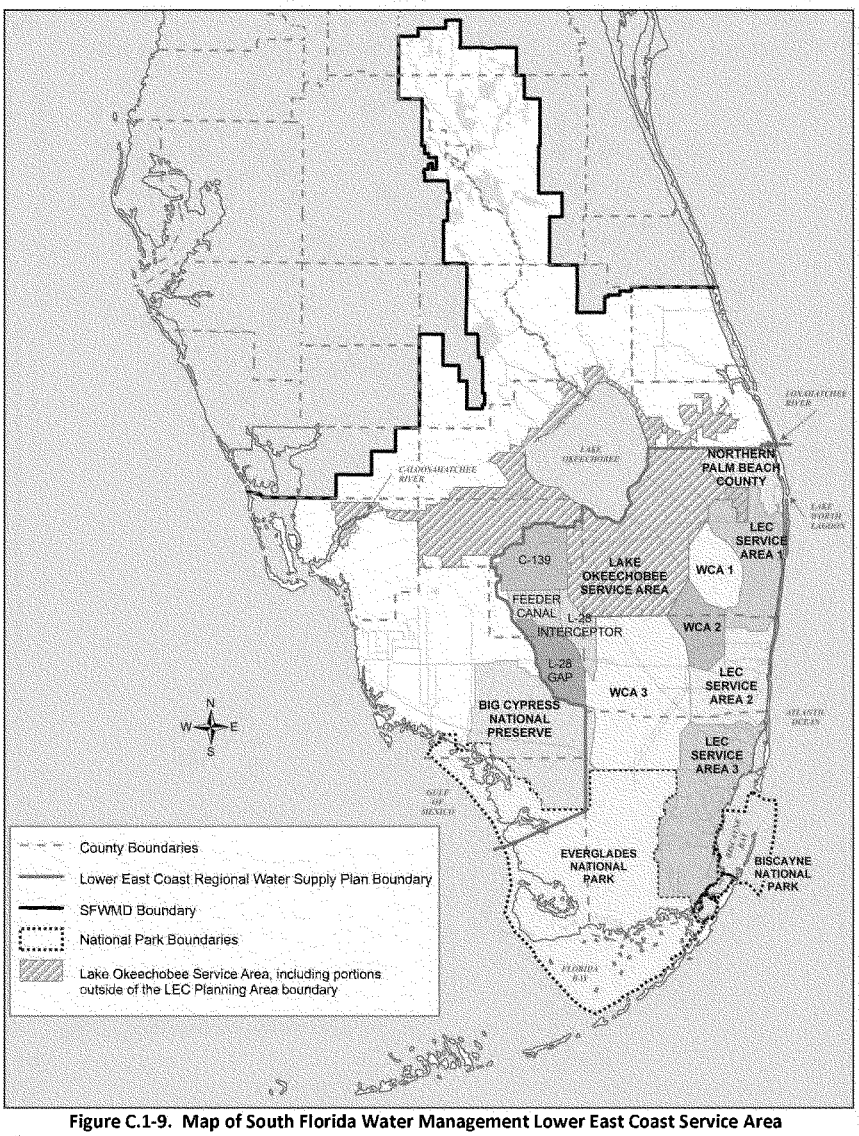


Figure C.1-9. Map of South Florida Water Management Lower East Coast Service Area

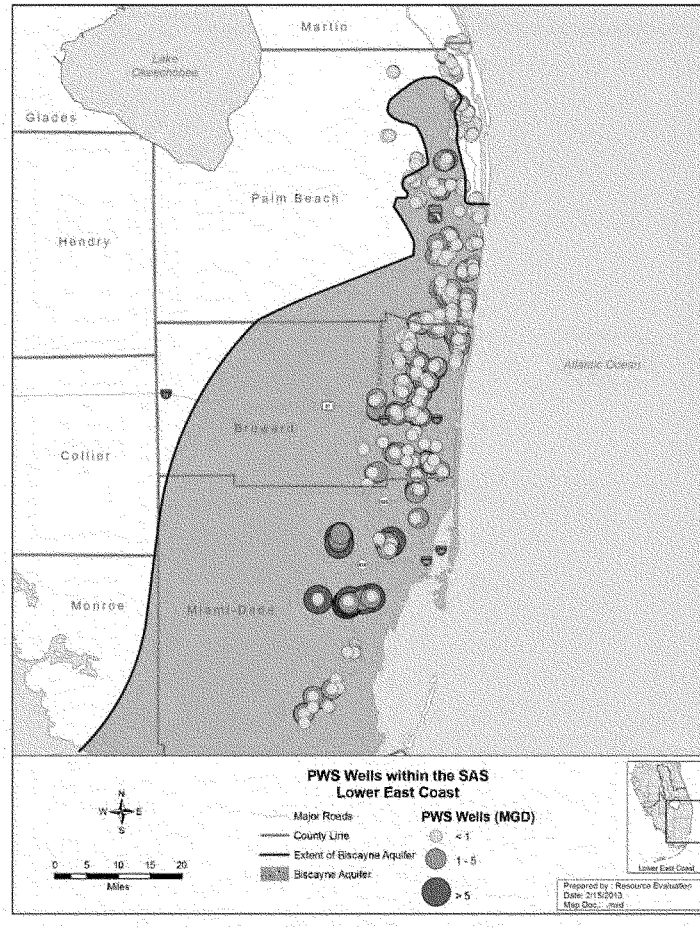


Figure C.1-10. Production from Lower East Coast Public Water Supply Wells

C.1.1.12 Water Quality

Water quality in the study area is significantly influenced by development. The C&SF Project led to significant changes in the landscape by opening large land tracts for urban development and agricultural uses, and by the construction of extensive drainage networks. Natural drainage patterns in the region have been disrupted by the extensive array of levees and canals which has resulted in further water quality degradation. The water quality of the study area is largely controlled by Lake Okeechobee and the EAA. Lake Okeechobee feeds downstream sub-basins such as the St. Lucie and Caloosahatchee River Estuaries, including Indian River Lagoon and Charlotte Harbor. The northern WCAs are fed from the lake as well as runoff from the EAA. Water quality impairment within the study area can generally be attributed to nutrients and bioavailable forms of mercury. A short discussion of each of these water

pollutants is provided below followed by a geographically referenced review of water quality within the study area.

C.1.1.12.1 Nutrients

Nutrients such as phosphorous and nitrogen compounds are a concern in the estuaries, WCAs, ENP, and Lake Okeechobee since they result in an imbalance of flora and fauna. To address nutrient discharges the Florida Department of Environmental Protection (FDEP) has recently established surface water quality numeric nutrient criteria for all Florida water bodies and developed National Pollution Discharge Elimination (NPDES) Total Daily Maximum Loads (TMDLs) for many watersheds with excessive nutrient pollution. TMDLs for phosphorus and/or nitrogen currently exist for Lake Okeechobee, the St. Lucie Estuary, and the Caloosahatchee Estuary. Within the Everglades Protection Area, phosphorus concentrations are regulated by the "Phosphorus Rule" 62-302.540 F.A.C. as well as addressed through legal agreements such as the 1991 Consent Decree and the 2012 Consent Order. (Additional detail on these two legal agreements is included in **Annex F**. Additional information on the status and implementation of TMDLs within the study area can be found at http://www.dep.state.fl.us/water/tmdl/.)

Excess nutrients come primarily from agricultural fertilizers; the decomposition of the peat soils in the area also contributes to excess phosphorus in the system. Phosphorus is the limiting nutrient for Lake Okeechobee, the WCAs, and ENP; nitrogen is generally considered to be the limiting nutrient for the marine waters of south Florida. Prior to 1970, the background TP concentration in Lake Okeechobee was less than 0.040 milligrams per liter (mg/l) while at present it exceeds 0.090 mg/l. Within the remnant Everglades, the background phosphorus concentration in surface waters is between 0.004 mg/l and 0.006 mg/l TP. At the northern end of WCA 3, inflow TP concentrations exceed 0.020 mg/l resulting in undesirable changes to soil composition and vegetation coverage. Soil phosphorus concentrations in pristine areas of ENP are on the order of 100 to 200 milligrams per kilogram (mg/kg) while in impacted areas of the WCAs near canals, soil phosphorus concentrations exceed 500 mg/kg (Craft 2007). The discharge of elevated concentrations of TP into the WCAs has resulted in sufficient soil phosphorus concentrations (< 650 mg/kg) to support cattail invasion into formerly sawgrass and bulrush dominated areas. An example of the impact of nutrient discharges is evident from the expansion of cattails south of the S-10 inflow gates to WCA 2A.

Nitrogen is generally not considered to be a problem within the Everglades landscape. The concentration of total nitrogen (TN) varies from about 2.2 mg/l in WCA 1 to around 0.85 mg/L in pristine areas of ENP. Lake Okeechobee TN concentration is presently around 1.7 mg/l. In the Caloosahatchee and St. Lucie estuaries and portions of Florida Bay, excess nutrients cause algal blooms and depressed oxygen conditions. The Caloosahatchee and St. Lucie Estuaries are generally considered to be nitrogen limited with inorganic forms of nitrogen such as nitrate causing the most harm. The concentration of nitrogen in the discharges from the C-43 and C-44 canals into the northern estuaries is approximately 1.5 mg/l with approximately 0.5 mg/l provided by the highly bioavailable inorganic forms such as nitrate and nitrite. The average concentration of total nitrogen into Florida Bay is around 1.0 mg/l with very little provided as nitrate and nitrite.

C.1.1.12.2 Mercury

Mercury (Hg) is widely distributed in the environment and originates primarily from volcanoes and human-induced (anthropogenic) sources such as combustion (Krabbenhoft and Sunderland, 2013). Hg is deposited from the atmosphere primarily as inorganic Hg. Approximately 55 percent of atmospheric Hg in the USA is sourced internationally with the balance coming from local anthropogenic sources.

Significant local sources include coal-burning power plants, cement kilns, and incinerators (FDEP, 2013). In the Everglades, the conversion of inorganic Hg to organic methylmercury (MeHg) is facilitated by naturally occurring reducing bacteria. This conversion of inorganic Hg to MeHg is one of the important steps in the bioaccumulation of Hg as it greatly increases toxicity and potential for accumulation in aquatic biota. Nearly all of the Hg found in fish and shellfish tissue is MeHg (Grieb et al., 1990; Bloom, 1992).

Human exposure to Hg is primarily through the consumption of fish and shellfish containing MeHg. Exposure to Hg causes neurodevelopmental delays in children. Wildlife exposure to MeHg through the consumption of fish results in reproductive, neurological, and immune system problems (Fleming et al. 1995; Tchounwou et al. 2003). However, contaminated fish is not the only pathway for bioaccumulation of Hg.

The United States Environmental Protection Agency (USEPA) has established that a concentration of Hg in fish tissue in excess of 0.3 mg/Kg is detrimental to human health. Water quality impairment for Hg is also measured by the incidence of gamefish tissue with Hg in excess of 0.3 mg/Kg. Twenty species of Florida freshwater fish and over 60 species of marine fish are under consumptive advisory (FDOH 2012). These advisories apply to the Everglades Protection Area (EPA), including all of the CEPP study area—WCAs and ENP (see **Figure C.1-11**, SFWMD 2008). In the WCAs, largemouth bass Total Mercury (THg) concentrations declined sharply in the 1990's, but have changed little since 2000. Significantly, in ENP, largemouth bass THg concentrations have not changed in the last 23 years, from 1989 to 2011. For the 2000-2011 period, about 70 percent of largemouth bass sampled from 49 locations within the EPA exceeded 0.3 mg/Kg and 75 percent of sunfish (several species) sampled from 25 locations in the EPA exceeded the USEPA trophic level 3 (TL3) MeHg wildlife protection guidance target of 0.077 mg/kg. The frequent exceedance of USEPA THg guidance levels LMB is evident in **Figure C.1-12.**

Methylmercury also poses a threat to fish-eating wildlife and species that prey on them such as wading birds, ospreys, eagles, otters and panthers. The elevated concentrations of MeHg in fish have been correlated with elevated concentrations in wildlife, including state and federally listed endangered species. Total Mercury concentrations in panther hair ranged from 0.092–67 mg/Kg; in wood stork chicks ranged from 5.2 to 10.8 mg/kg, at coastal ENP colonies; in great egrets ranged from 2.5 to 20 mg/Kg, from several colonies in the EPA (2013 and 2014 SFER, SFWMD).

In 2013, Florida adopted a statewide TMDL for Hg to protect public health with respect to fish consumption. This state program proposes achieving Hg target levels in fish tissue by reducing atmospheric Hg emissions by 86%, which may encompass reduction in emissions from sources in south Florida, statewide, other U.S. states, and other countries.

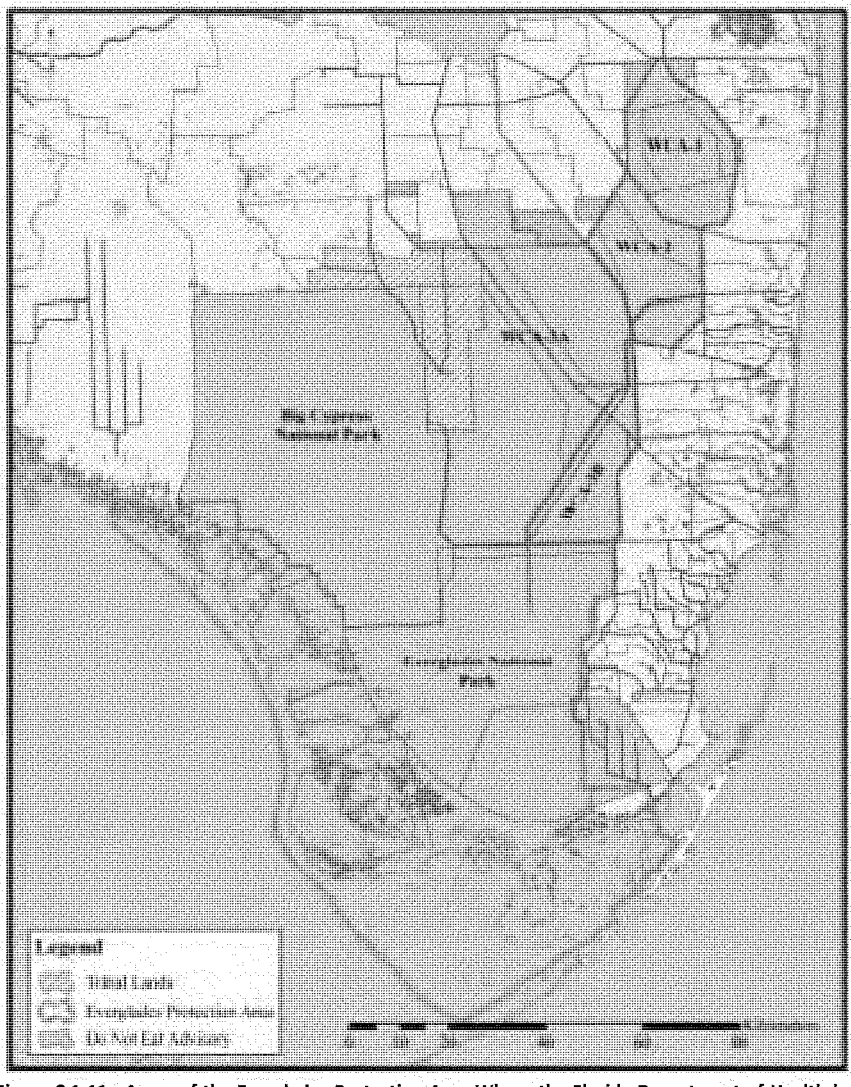


Figure C.1-11. Areas of the Everglades Protection Area Where the Florida Department of Health has issued "Do Not Eat" Advisories for Largemouth Bass (Source 2009 South Florida Environmental Report).

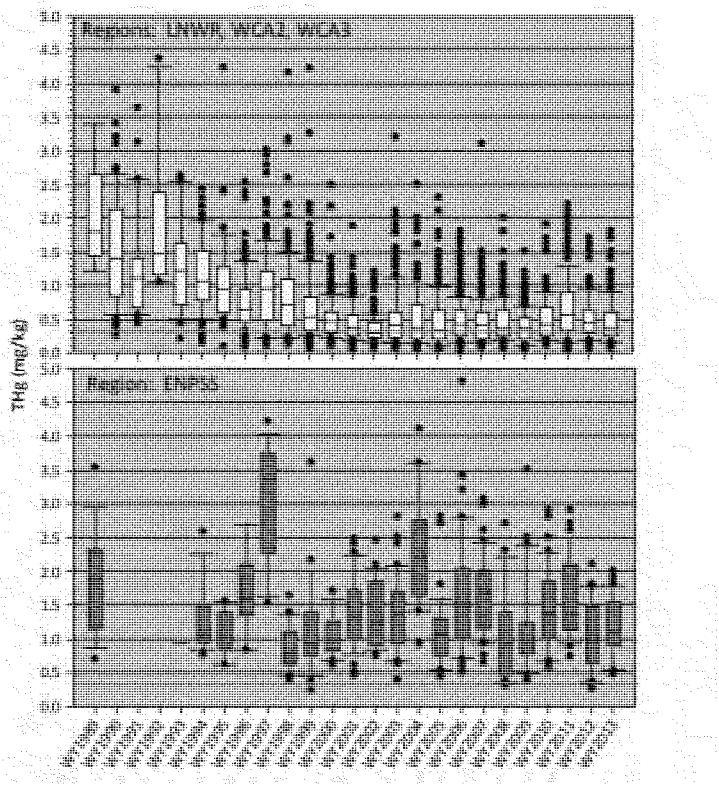


Figure C.1-12. Total Mercury (THg) Concentrations in Largemouth Bass from the Everglades Protection Area, Water Year 1989-2013. The top figure shows the WCAs and bottom figure ENP. Redlines (0.3 mg/kg) are USEPA recommended MeHg levels for the protection of human health. Modified from the 2014 South Florida Environmental Report.

Over the past 15+ years, several agencies, educational institutions and organizations have conducted research to identify key chemical characteristics that play major roles in Hg methylation and have investigated trends in MeHg bioaccumulation within the Everglades freshwater ecosystems as well. Sulfur, Hg and dissolved organic carbon, have been identified as significant drivers of Hg methylation (Ekstrom et al., 2003; Gilmour et al., 2004b). It has been suggested that sulfate-reducing bacteria (SRB) are the dominant producer of MeHg in the Everglades aquatic ecosystems, however other groups of bacteria such as iron-reducing bacteria and methanogens also have the ability to methylate mercury (Gilmour 2012).

Previous studies on mercury methylation have indicated that sulfate-reducing bacteria may produce MeHg within a range of sulfate levels. Some research and field observations in the Everglades marshes suggested that at 1 mg/L sulfate, microbial sulfate reduction and MeHg production rates would be low

due to sulfate limitation (Gilmour et al., 2007a, and b). By contrast, above 2 mg/L sulfate, the ecological risk to the ecosystem increases because at intermediate levels of sulfate the Hg methylation is optimized. Some recent studies further suggest that mercury methylation rates are optimum (higher) at sulfate concentrations ranging from 10–20 mg/L in the WCAs and 2–4 mg/L in ENP; these methylation rates, however, become depressed when sulfide levels increase (300 µg/L) above the normal range (5–150 µg/L; Gilmour et al., 1998; Benoit et al., 2003; Gilmour et al., 2007a).

However, there is evidence that high MeHg concentrations in surface water or fish could occur at very low sulfate levels. For example, a mesocosm study conducted in a north-central Minnesota peatland showed that MeHg production increased by over two-fold when the porewater sulfate level was raised from 0.06 mg/L to 1.3 mg/L (Mitchell et al. 2008a). A field investigation on the same study area revealed that MeHg hotspots typically formed at the median SO_4 concentrations between 0.1 and 3.0 mg/L (Mitchell et al. 2008b). Similar results can also be found in the Florida's Everglades. A recent Hg and sulfate enrichment incubation with slurry collected from WCA 3A showed significantly elevated MeHg production at the sulfate level below 1 mg/L (DBE 2013). In addition, consistently high THg levels in fish and low surface water sulfate levels (at or below 1 mg/L) were observed in a long-term mercury monitoring site (3A15) within the WCA-3A (Julian et al. 2014). By contrast, high MeHg concentrations in the surface water or fish are also found at sulfate level well above the "optimal" range (i.e., 20 mg/L) in south Florida wetlands. Rumbold and Fink (2008) reported extremely high MeHg concentration (20 ng/L) in the surface water of Cell 1 of STA-2 after a period of dryout. During this time period (CY2002), sulfate concentration at inflow varied from 40.5 to 95.2 mg/L (SFWMD DBHYDRO Database). Another example of long-term Hg hotspot in largemouth bass which consistently exceeded USEPA trophic level 4 fish criterion (0.346 mg/kg) is found at U3 of WCA 2A where annual average sulfate concentration remained at or above 20 mg/L except WY2007 and 2008 (Julian et al. 2014). These findings suggest that mercury methylation and bioaccumulation in Everglades fish involve complex biogeochemical and ecological processes that are affected by factors other than sulfur. Additional research and monitoring are needed to provide a better understanding of the mechanisms influencing mercury methylation under the varying biogeochemical and ecological conditions found in the Everglades.

The historic background sulfate level in the Everglades may be lower than 1 mg/L in some locations (≤0.1 mg/L; Scheidt and Kalla, 2007; Weaver et al., 2007). At present time, major sources of sulfate to the EPA include EAA runoff and Lake Okeechobee discharge. Sulfate concentrations within Lake Okeechobee, the EAA, and portions of the WCAs and ENP are well above the natural background levels (Julian et. al 2014). On the basis of recently developed sulfur budgets, Lake Okeechobee contributes from 16 to 30% of the sulfur loading to the EAA (Corrales et. al., 2011; James and McCormick, 2012) and farmers' applications and soil oxidation contribute an additional 11% and 45%, respectively (Corrales et. al., 2011). Other discharges that contribute to the EPA sulfate loading come from basins to the east as well as agricultural lands to the west. In the early 1990s, the lake average sulfate level was estimated at around 60 mg/L; estimates of current lake sulfate levels range from 41–50 mg/L James and McCormick (2012). By comparison, Julian et al. (2014) reported that sulfate in discharges into WCA 1 was 51 mg/L, 34 mg/L in WCA 2, 22 mg/L in WCA-3, and 4 mg/L in ENP during the WY2013. Other sources of sulfate to the EPA include atmospheric deposition, groundwater, connate seawater and soil oxidation. Atmospheric deposition alone accounts for about 1 mg/L sulfate load to the surface water of EPA. Another factor that may lead to increased sulfate concentration in the EPA marshes without additional loading is surface water evaporation and evapotranspiration by aquatic plants. The evaporation process contributes to the outflow sulfate concentration from Lake Okeechobee being higher than the inflow concentration (James and McCormick, 2012). The contributions of evaporation/evapotranspiration, connate seawater, soil oxidation and groundwater to the Everglades' sulfur budget need further

quantification. These sources of sulfate, which are largely uncontrollable, could contribute to enhanced mercury methylation in portions of the Everglades.

There are no numeric state water quality criteria for sulfur that are applicable to the Everglades. The USEPA has a nationally recommended surface water quality criterion for sulfide (2 µg/L) but not for sulfate, and the state of Florida has neither a sulfate nor a sulfide numeric water quality. Both sulfate and sulfide are relevant forms of sulfur because they can act as agents stimulating and inhibiting, respectively, Hg methylation in some locations of the Everglades ecosystem.

Several studies have focused on a hypothetical S-MeHg unimodal relationship between surface water sulfate and biota MeHg in the Everglades. The relationship, originally developed based on sediment MeHg and surface water sulfate concentrations, indicates that methyl mercury production strikes a balance between sulfate limiting and sulfide inhibiting the methylation of mercury (Gilmour and Henry 1991). Although some Everglades data support this relationship (Axelrad, et al., 2013), ambient data from the Everglades ecosystem also cover wide variations and do not follow this relationship in a predictable manner (Julian, et al., 2014).

Water quality conditions across the EPA vary greatly, primarily due to differences in water quality conditions of surface water inflow (Julian et al., 2013; Scheidt and Kalla, 2007). Areas within WCA 3 and ENP with low to moderate sulfate concentrations can have a highly variable concentrations of fish tissue mercury within the three indicator fish species (i.e. mosquitofish, sunfish, largemouth bass; Julian et al., 2014). This trend is consistent with trends present within the USEPA R-EMAP dataset associated with mosquitofish Hg concentrations as presented by Julian (2013). Sulfur is one of many factors that can affect mercury methylation and bioaccumulation in the Everglades.

C.1.1.12.3 Lake Okeechobee

Lake Okeechobee is considered to be the hydrologic heart of south Florida. Water quality in the lake has been greatly impacted over the long-term by agricultural operations in the Kissimmee Basin to the north and the EAA to the south. Hurricane events adversely affect the lake water quality. After the hurricanes of 2004 and 2005 which passed directly over the lake, the average TP concentration increased to more than 200 parts per billion (ppb). This was due to re-suspension of some of the 30,000 tons of TP stored in the lake sediments. Current phosphorus loading to the lake is approximately 377 tons per year and the average TP concentration for the lake is currently around 92 ppb which is the lowest average concentration since 1993 (SFWMD 2013). The average total nitrogen concentration in the lake is approximately 1.4 mg/l. The FDEP has determined that the lake is impaired for nutrients and mercury in fish tissue. To date, the FDEP has established a TP loading TMDL for Lake Okeechobee with a target annual load of 140 tons per year and a target in-lake total phosphorus concentration of 40 ppb. The 40 ppb TP target was established as the level of phosphorus necessary to reduce algal blooms to less than 10 percent of the time (Havens, K.E. & Walker, W.W. 2002). Control of nitrogen inputs has not been the focus in the Lake Okeechobee basin to date. The SFWMD, in concert with FDEP and FDAC, have put together the Lake Okeechobee Protection Plan (LOPP) which describes the State's plan to achieve the TP loading TMDL for the lake (SFWMD 2011). Since the Lake Okeechobee Protection Act was enacted in 2000, over $1 billion of state and Federal contributions have been invested in the Lake Okeechobee watershed to implement nutrient removal, water storage/retention, and restoration activities in the Lake Okeechobee Watershed including, but not limited to:

- Land owners enrolled approximately 1.6 million acres (77 percent of agricultural land in the Lake Okeechobee watershed) in the FDACS adopted agricultural best management

practices (BMP) program. Agricultural BMPS are practical, cost-effective actions that agricultural businesses can use to reduce pesticides, fertilizers, animal waste and other pollutants entering our water resources.

- FDEP adopted amendments to Chapter 62-640, Florida Administrative Code (F.A.C.), to improve statewide application site accountability and management of Class B biosolids. The rule changes included requirements for site permitting, nutrient management plans, and the biosolids provisions of the 2007 legislation for Sec. 373.4595, F.S., which have resulted in a shift away from biosolids land application in the Okeechobee watershed. Since 2007, the number of active biosolids sites has decreased from 22 to 0. There are currently no permitted biosolids sites in the northern Everglades.
- Extensive data collection and technical analyses are near completion for the development of performance measures for the watershed's Pollutant Source Control Programs. This was a necessary first step in support of technical amendments to the District's regulatory program. The next step includes adoption of schedules, strategies and technical methodologies for fully implementing source controls and BMP programs (for non-FDACS participants) and quantitatively measuring the combined source control programs progress toward achieving water quality goals.
- Construction of three regional STAs designed to reduce phosphorus loading to Lake Okeechobee. These STAs are also expected to remove total nitrogen from the system.
- Implementation of six Hybrid Wetland Treatment Technology (HWTT) projects. HWTT combines the strength of both wetland and chemical treatments to maximize nutrient removal while minimizing chemical use. Based on monitoring results of the six operational HWTT projects in the northern Everglades, this effort is proving to be a promising technology. During the entire study period, results showed flow-weighted mean total phosphorus (TP) concentrations reductions of approximately 70-90 percent and total nitrogen reductions of approximately 20 to 60 percent (SFWMD, 2011).
- Approximately 138,000 acre-feet of water storage/retention has been achieved in the northern Everglades and connected watersheds since 2005 through partnerships that have provided water management alternatives and regional and sub-regional projects. Of that, approximately 91,700 acre-feet is located within the Lake Okeechobee Watershed. Additional water storage sites are currently being developed as part of the Dispersed Water Management program.
- The Northern Everglades-Payment for Environmental Services (NE-PES) program is part of the Dispersed Water Management program. The goal of the NE-PES is to establish creative collaborations via contracts with private landowners to obtain the water management services of water and nutrient retention which will reduce excess flows and nutrient loads to Lake Okeechobee and the estuaries. Payment for documented services is an innovative approach to achieve water resource improvements while providing a business opportunity for landowners to participate.
- Construction of more than 30 phosphorus reduction projects including isolated wetland restorations, Dairy Best Available Technology projects, former dairy remediation projects, evaluation of new technologies, and public-private partnership projects.
- Removal of approximately 1.9 million cubic yards of muck from Lake Okeechobee, in conjunction with the Florida Fish and Wildlife Conservation Commission (FWC), exposing thousands of acres of natural lake bottom sand and promoting the return of native plant

species. These efforts were estimated to remove approximately 142 metric tons of phosphorus from the lake.

- Acquisition of more than 100,000 acres of land needed for Kissimmee River Restoration and Headwaters Revitalization is substantially complete. Three phases of the Kissimmee River Restoration Project have been completed. The remaining phases are scheduled to be complete in 2015. Once restoration construction is complete, 40 square miles of Kissimmee River and floodplain ecosystem will be restored including almost 25,000 acres of wetlands and 40 miles of historic river channel.

The State of Florida's current plan (2011 to 2013) includes source control efforts, sub-regional and regional treatment works, and storage implementation projects which will reduce TP loads to the lake by approximately 57 metric tons (mTons)/year. The long-term plan (post 2013) outlined in the 2011 LOPP includes projects that are expected to remove an additional 132 mTons/year of TP (excluding the CERP Lake Okeechobee Watershed Project). The removal of the remaining 116 m Tons/year necessary to achieve the TMDL is expected to be achieved by implementing features included in the CERP Lake Okeechobee Watershed Project as well as undertaking additional measures associated with expanding the ongoing efforts as well as implementing new treatment technologies.

Like many of Florida's freshwater lakes, Lake Okeechobee is impaired for mercury due to elevated levels of mercury found in fish. The FDOH advises limiting the consumption of fish caught from the lake.

C.1.1.12.4 Caloosahatchee River and Estuary

Water quality conditions are degraded in the upper and lower areas of the Caloosahatchee River basin due to agricultural and urban runoff, respectively. The channelized section of the river also shows degraded water quality conditions, due to agricultural inputs, as compared to tributaries lying in less developed areas of the basin. Problems associated with the degraded areas of the basin are typified by low dissolved oxygen levels, elevated conductivity, decreased biodiversity, and mercury methylation / bioaccumulation. Conditions in the urbanized sections of the basin are influenced by non-point stormwater flows, and are manifested in the river by elevated chlorophyll levels, algal blooms, periodic fish kills, and low dissolved oxygen levels. Although wastewater discharges remain a problem, the estuary is presently more seriously affected by high nutrient waters from the river and tributaries, and stormwater runoff from cities. Nutrient and chlorophyll levels are high, and small algal blooms occur regularly.

Lake Okeechobee provides approximately 60 percent of the freshwater discharged at the S-79 structure which is the upstream end of the Caloosahatchee Estuary. The remaining volume of freshwater comes from Caloosahatchee River basin runoff. FDEP has identified mercury in fish tissue, nutrients, and dissolved oxygen as verified impairments to the main stem of the Caloosahatchee Estuary. Approximately two-thirds of the nutrient load to the Caloosahatchee Estuary is contributed from sources within the basin with the remaining fraction coming from Lake Okeechobee. Given that the estuary is nitrogen limited, FDEP has focused on controlling nitrogen loads to improve water quality. FDEP has developed a TMDL for TN in the estuary that requires a reduction in load of 23% relative to the current average annual load of 5,900 tons per year. FDOH has a fish mercury consumption advisory for the Caloosahatchee River and Estuary.

C.1.1.12.5 St Lucie River and Estuary

Water quality conditions along the St. Lucie River are rated as good in less developed areas of the basin. However, conditions are degraded in urbanized areas and along the extensive network of canals that drain this area. The worst water quality conditions in Martin and St. Lucie Counties are reported in the St. Lucie River and the canals leading from the EAA. Approximately 33 percent of total freshwater flow to the St. Lucie Estuary is provided by discharges from Lake Okeechobee through the C-44 Canal. Given its similarity to the Caloosahatchee Basin, it is reasonable to assume that at least 50% of the nutrient load comes from the St. Lucie Basin with the remainder provided by Lake Okeechobee flows. FDEP has determined that the St. Lucie River is impaired for Biochemical Oxygen Demand (BOD), TP, and TN. For the C-44 canal, FDEP established TMDL's for BOD, TP, and TN that require a reduction in load of 70, 55, and 51 percent, respectively from current conditions. Upstream portions of the St. Lucie River are impaired for mercury; however, the main portion of the St. Lucie Estuary is not included in the FDOH list of fish consumption advisories for mercury.

C.1.1.12.6 Everglades Agricultural Area

Sugar cane is grown on approximately 85 percent of the 700,000-acre EAA with the balance planted in turf grass, rice, citrus, and truck crops. The L-8, West Palm Beach, Hillsboro, North New River, and Miami Canals from Lake Okeechobee to the L-4, 5, 6, and 7 Canals, which roughly define the EAA, have poor water quality with extremely high nutrient and low dissolved oxygen levels. Other problems include pesticides, biological oxygen demand, bacteria, suspended solids, and mercury bioaccumulation. FDEP has defined most of the primary and secondary canals within the EAA (Miami, Hillsboro, North New River, West Palm Beach, Bolles, and Cross Canals) as Class III Waters with a designated use of "recreation propagation and maintenance of healthy, well-balanced population of fish and wildlife. FDEP has identified fecal coliform, ammonia, and nutrients as impaired within portions of the EAA". No draft or final TMDLs have been established for the EAA; however, as a result of extensive litigation between the State of Florida and Federal Agencies (DOI, USEPA) and other parties over the last 20 years, the State has been compelled to establish numeric criteria for total phosphorus, implement agricultural BMPs to control phosphorus discharges and build stormwater treatment systems to ensure that water leaving the EAA and entering the WCAs meets the criteria. Over the past 12 years, SFWMD has constructed approximately 60,000 acres of stormwater treatment areas to reduce total phosphorus concentration in water entering the WCAs. While the construction and operation of the STAs have significantly improved the quality of water discharged to the WCAs, the Federal Parties (DOI, USEPA) filed a brief with the Court for additional relief given continued exceedances of the original 1991 Settlement Agreement water quality limits. In 2011, the presiding judge ordered the parties to come to terms or have a settlement imposed upon them. The September 2012 Consent Order issued to the SFWMD by FDEP is the result of extensive negotiations between the state and Federal parties. The Order requires that the maximum annual flow weighted mean TP concentration be no higher than 19 ppb on an annual basis and a long-term limit of no higher than 13 ppb in three out of five years. To date, the TP concentration in the best performing STA has averaged 17 ppb which exceeds the long-term limit of 13 ppb (SFWMD, 2012b). As part of the 2012 Consent Order, the SFWMD has agreed to construct 6,500 acres of additional STA capacity and 110,000 acre-feet of FEB storage. In addition, the SFWMD has to implement measures to improve the performance of the existing STA facilities. The SFWMD's plan for complying with the 2012 Consent Order is outlined in their "Restoration Strategies" plan (SFWMD 2012c).

SFWMD maintains a water quality monitoring network for surface waters within and at the boundaries of the EAA. These water quality data are compiled in SFWMD's database DBHYDRO and available through Internet search (http://www.sfwmd.gov/org/ema/dbhydro/). The SFWMD and FDEP jointly publish the South Florida Environmental Report (SFER) which includes a summary of water quality

conditions in south Florida (http://my.sfwmd.gov/portal/page/portal/xweb%20about%20us/agency%20reports). Additional data sources include: USEPA, USGS, FDEP, and numerous public and private research and monitoring efforts.

C.1.1.12.7 Greater Everglades

Water from Lake Okeechobee and the EAA flows through the WCAs to ENP and eventually into the coastal bays and estuaries. The 2011 SFWMD South Florida Environmental Report (SFER) reported water quality exceedances for ammonia, dissolved oxygen, alkalinity, pH, and specific conductance in WY2010 (SFWMD 2011b). Ten pesticides were detected in samples; however, only atrazine was detected at a concentration exceeding its toxicity based guideline at locations within WCA 1 and WCA 2. Mercury in fish tissue is a concern for all of the WCAs. Fish tissue levels of methylmercury in the WCAs have been above the USEPA human health criterion of 0.3 mg/kg for 50 percent of bass collected since 1998. Mercury levels in fish have fallen significantly over the past 15 to 20 years in the WCAs (58% relative to 1991) and ENP (43% relative to 1997) (SFWMD 2012b). The FDOH has published a "no consumption" advisory for portions of the Greater Everglades due to elevated fish tissue mercury concentrations.

Nutrient loading to the WCAs and ENP have resulted in significant degradation of the Everglades landscape by converting thousands of acres of sawgrass prairie into lesser quality habitat such as cattail marsh. The 1991 Everglades Settlement Agreement (SA) ended a 1988 Everglades lawsuit (Case No. 88-1886-CIV-Hoeveler) that was brought forward by the Federal government against the State of Florida (SFWMD and FDEP 1988) for failing to regulate discharges into ENP and the Arthur B. Marshall Loxahatchee National Wildlife Refuge. The subsequent 1992 Consent Decree, as modified in 1995, specified interim and long-term phosphorus concentration levels for the Arthur R. Marshall Loxahatchee National Wildlife Refuge, SRS, Taylor Slough and coastal basins in ENP. The SFWMD collects the required water quality data and publishes a Settlement Agreement Report on a quarterly basis as part of complying with the terms of the 1992 Consent Decree. For the last several years, discharges into the EPA have mostly complied with the requirements of the settlement agreement with the following exceptions: (1) exceedance of the June 2009 limit for Loxahatchee, and (2) exceedance of the allowable annual percentage of TP measurements exceeding 10 ppb at SRS for WY2010. In addition, the SRS Settlement Agreement calculations for WY2009 and WY2010 show that the annual flow-weighted mean TP concentration for these years was at the limits (8.2 ppb and 8.9 ppb, respectively for WY2009 and WY2010).

Compliance with the SA criteria at SRS is one of the most contentious issues for the state, Federal and Tribal parties. Recent water quality trends in WCA 3A indicate that flow-weighted mean (FWM) TP concentrations and SRS loads are decreasing (Walker 2010). **Figure C.1-13** shows that over the past 20 years, the annual FWM TP concentrations entering WCA 3A have fallen from approximately 0.050 mg/l to 0.030 mg/l while the annual FWM TP concentration measured at SRS has fallen from approximately 0.011 mg/l to approximately 0.009 mg/l. The reduction in inflow FWM and outflow FWM for WCA 3A is likely the result of the construction and operation of the STAs in the EAA. This is a slow trend and there may be periodic reversals due to weather conditions (e.g. droughts resulting in WCA dry downs, followed by wet periods flushing the mobilized nutrients). In portions of the WCAs that have historically received direct untreated discharges from the EAA, there is a large internal phosphorus load contained in the sediments. This large internal load may become a source of water column TP as inflow TP concentrations from the STAs are reduced below the 13 ppb and the sediment/pore water TP equilibrates with the water column TP.

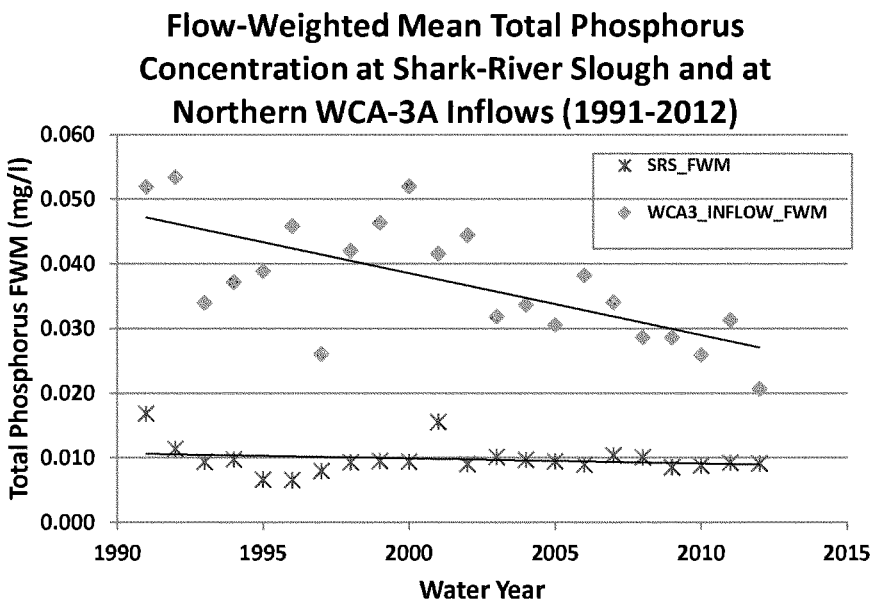


Figure C.1-13. Flow-Weighted Mean Total Phosphorous Concentration at Shark River Slough and Northern WCA 3A Inflows

C.1.1.13 Groundwater Resources

Groundwater in south Florida consists of the surficial Biscayne aquifer and the Floridan aquifer. Both are critical to the ecology and economy of south Florida. The Biscayne aquifer is highly permeable and is at or near the land surface in many locations and therefore readily susceptible to groundwater contamination. The Biscayne aquifer has been classified as a Sole Source Aquifer for Broward and Miami-Dade Counties under the Federal Safe Drinking Water Act based on the aquifer's susceptibility to contamination and the fact that it is a principal source of drinking water. The Floridan aquifer system is one of the most productive aquifers in the world and is a multi-use aquifer system. North of Moore Haven and Port Mayaca, where it contains freshwater, the Floridan is the principal source of groundwater supply. South of Lake Okeechobee, the Floridan aquifer is generally brackish and historically has not been used as a primary source of drinking water though this may change in the future as water supplies become more scarce.

C.1.1.14 Air Quality

Legal limitations on pollutant concentration levels allowed to occur in the ambient air, or air quality standards, have been established by the USEPA and the FDEP for six criteria pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particle pollution (10 microns or less in diameter (PM_{10}), and 2.5 microns or less in diameter ($PM_{2.5}$), and sulfur dioxide (SO_2). Primary sources of air pollution in south Florida are related to transportation, stationary fuel combustion sources, and solid waste disposal. The existing air quality within south Florida is considered good, as outlined within

the FDEP 2010 Air Monitoring Report (FDEP 2010). Air monitoring reports are prepared annually by FDEP to inform the public of the air pollutant levels throughout the State of Florida. The report summarizes the results of monitoring that has been conducted to measure outdoor concentrations of those pollutants for which the USEPA and the State of Florida's Environmental Protection program have established ambient air quality standards. All areas within the state are designated with respect to each of the six pollutants as attainment (i.e., in compliance with the standards); non-attainment (i.e., not in compliance with the standards); or unclassifiable (i.e., insufficient data to classify). Attainment areas can be further classified as maintenance areas. Maintenance areas are areas previously classified as non-attainment which have successfully reduced air pollutant concentrations to below the standard. Maintenance areas must maintain some of the non-attainment area plans to stay in compliance with the standards.

Southeast Florida including Miami-Dade, Broward, and Palm Beach Counties continue to be classified by the USEPA as attainment/maintenance areas for ozone. Florida remains designated as unclassifiable for PM_{10}. Although sufficient data have been collected for attainment determinations, USEPA has not considered PM_{10} for attainment determinations in Florida yet.

C.1.1.15 Hazardous, Toxic or Radioactive Wastes

Engineering Regulation (ER) 1165-2-132 states that "construction of civil works projects in HTRW contaminated areas should be avoided where practicable." Compliance with the requirements of ER 1165-2-132 for the planning phase is demonstrated in this report. The USACE and SFWMD will continue to document HTRW conditions on the project lands such that the project will be in compliance with the ER and other applicable HTRW policies. In order to comply with the requirements of ER 1165-2-132, human health risks are typically evaluated by comparing chemical concentrations in all media (e.g., soil, groundwater, surface water, sediment) to human health-based cleanup target levels (CTLs) promulgated by FDEP in Chapter 62-777, F.A.C. Ecological risks are typically evaluated by comparing chemical concentrations to the Sediment Quality Assessment Guidelines (SQAGs) developed by FDEP for inland waters and to ecological restoration targets established by the USFWS. If warranted, lands within the project boundary are investigated in accordance with the jointly developed (FDEP, USFWS, and SFWMD) protocol, entitled "Protocol for Assessment, Remediation and Post-remediation Monitoring for Environmental Contaminants on Everglades Restoration Projects" (SFWMD 2008). The protocol, which is commonly referred to as the Ecological Risk Assessment (ERA) Protocol, is intended to provide guidance on conducting environmental site assessments on agricultural lands proposed for use in projects to be inundated with water, such as for conversion to storm water treatment areas, wetlands, reservoirs, and other aquatic features.

The ERA Protocol requires that relevant data collected during the Phase II ESA initially be compared to the human health Soil Cleanup Target Levels (SCTLs) from 62-777 F.A.C. and the ecological risk SQAG thresholds. While the SCTL's are promulgated standards under Florida law, the SQAG guidelines are not standards as defined in Section 403.803, F.S. where the results exceed the SCTLs, a risk-based approach is used by the regulator to determine if corrective action is required or if an alternative target level is appropriate based on projected exposure. Where the results exceed the SQAG screening criteria, a Screening Level Ecological Risk Assessment (SLERA) is performed as part of the Phase II ESA. The purpose of the SLERA is to evaluate potential ecological risks to benthic invertebrates and higher trophic species, particularly USFWS trust species protected under the Endangered Species Act or the Migratory Bird Treaty Act, associated with exposure to the chemicals present in the soils, after the project is constructed and the property is inundated.

A summary of the HTRW conditions in the four major areas of the project footprint are provided below.

C.1.1.15.1 A-2 Flow Equalization Basin Lands

The land for the proposed A-2 Flow Equalization Basin is located along the west side of US 27 South in unincorporated Palm Beach County and encompasses approximately 14,408 acres. The project lands consist of eight separate parcels currently owned by the State of Florida. The tract numbers, prior ownership, and acreage are shown in the **Table C.1-4** below.

Table C.1-4. Prior Ownership for A-2 Flowage Equalization Basin

A-2 Flow Equalization Basin		
Tract No.	Former Owner	Acreage
D7100-044	TALISMAN SUGAR CORPORATION	2
D7100-047	TALISMAN SUGAR CORPORATION	10
D7100-066	TALISMAN SUGAR CORPORATION	12
D7100-067	TALISMAN SUGAR CORPORATION	1
D7100-104	TALISMAN SUGAR CORPORATION	14,371.53[2]
D7100-139	TALISMAN SUGAR CORPORATION	1
D7100-141	WEINLEIN, JOAN	10
D7200-005	TALISMAN SUGAR CORPORATION	1
A-2 Total		**14,408.53**

The primary parcel (Tract D7100-104) was acquired from Talisman Sugar Company in 1999 by the SFWMD. Several of the smaller parcels listed above were also owned and operated by Talisman Sugar Corporation, but these parcels were deferred from transfer during the original transaction until environmental concerns on these small areas could be addressed. The Weinlan parcel (Tract D7100-141) was leased to Talisman Sugar at the time of the 1999 acquisition and was evaluated with the remainder of Tract D7100-104. Most of the project area has been historically cultivated in sugar cane, with occasional rotational crops of rice or corn. The property is currently under lease to New Hope Sugar Corporation for sugar cane cultivation. **Figure C.1-14** shows the site location and the parcel numbers.

The September 2012 Summary Environmental Report (PSI, 2012), the March 2013 Phase II Environmental Assessment Report (PSI, 2013a), and the May 2013 Phase II Environmental Site Assessment Report-Addendum #1 (PSI, 2013b) provide a review of the past audits and closure reports as well as the results of the cultivated soil sampling that was conducted in January of 2013. The reports cited above is the source for all of the tables and figures included within this section. Copies of these reports as well as related correspondence are found in **Annex H (Hazardous Toxic and Radioactive Wastes)**.

[2] Acreages shown include only the portion of the tract that is within the proposed limits of construction for the A-2 FEB project. The total acreage of Tract D7100-104 is 20,525 acres, and includes lands outside the current project footprint.

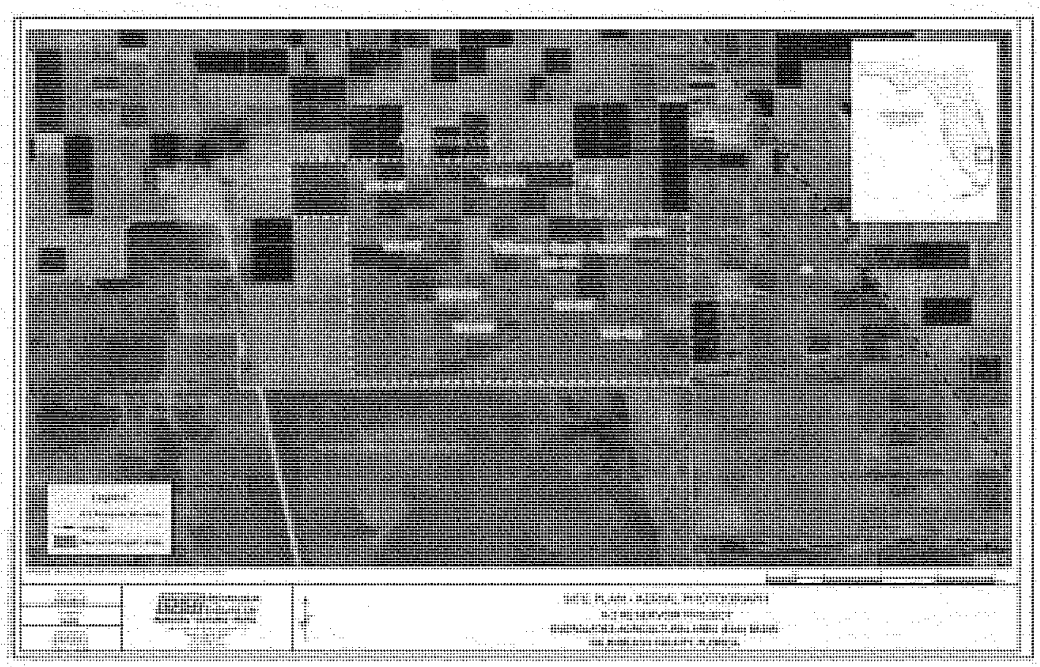


Figure C.1-14. A-2 Reservoir Tracts (PSI INC. 2012)

911

Table C.1-5 includes a list of the HTRW sites found on the subject property and the disposition of the remedial actions taken at each of these sites since 1999. **Figure C.1-15** shows the locations of each of these sites within the A-2 footprint. The borrow pit was used in the past for disposal of solid wastes. Arsenic, lead, phenols, and petroleum hydrocarbons were found at the borrow pit. Approximately 8,100 tons of solid waste and contaminated soil was removed from this site. A groundwater treatment system was installed to remove lead but it was not fully successful. The FDEP issued a Conditional Site Remediation Closure Order (CSRCO) in July of 2012. This Order included a Non-residential Deed Restriction. **Figure C.1-16** shows the location of this deed restriction. The borrow pit is designated as T-2 on this figure.

Arsenic, petroleum hydrocarbons, and pesticides were found at the labor camp which included a pesticide mix/load site. Approximately 3,600 tons of soil was removed from the labor camp. Petroleum contamination of the groundwater was naturally attenuated and pesticide impacts to groundwater were addressed through soil removal. The FDEP issued CSRCO in July of 2006 that includes a non-residential deed restriction. **Figure C.1-16** shows the location of this deed restriction. The labor camp is designated as T-3 on the figure.

Four of the identified HTRW sites are former pump station locations. Approximately 7 tons of petroleum contaminated soils were removed from these sites. Soil samples collected at two of these pump stations were tested for the presence of organo-chlorine pesticides and no exceedances were found. The FDEP issued Site Remediation Closure Orders (SRCO) at these pump stations in December of 1999.

A pesticide mix/load area was investigated and arsenic contamination was detected in the soils. Approximately 700 tons of arsenic impacted soils were removed from the site and a groundwater pump/treat system was operated for three months at which point the groundwater arsenic concentration was below the applicable groundwater concentration target level (GCTL). The FDEP issued a CSRCO in July of 2006 and included a non-residential deed restriction. The location of the site is shown in **Figure C.1-16**. The pesticide mix/load area is designated as T-21 on the figure.

Table C.1-5. Summary of Assessment and Corrective Actions, A-2 Flowage Equalization Basin Lands, Palm Beach County (Adapted from PSI Inc. 2012).

Tract Nos.	Point Source RECs Identified in Phase I	Soil / GW Exceedances Identified in Phase II	Corrective Action Summary	Regulatory Concurrence
D7100-104, -044, -047, -066, -067, -139, -141, -005	Borrow Pit (T-2)	Arsenic and petroleum hydrocarbons detected above SCTLs, phenols and m & p cresol detected above GCTLs	Excavated: 1,009 tons of steel, 473 tons of tires, 3,895 tons of C & D debris, 3,735 tons of soil. Also installed GW treatment system (operation was abandoned due to inability to filter out lead)	CSRCO, 7-21-06, Soil above SCTL, with Non-residential Deed Restriction
	Labor Camp (T-3)	Arsenic and petroleum hydrocarbons detected above SCTLs at burn pit area and drum storage area within labor camp. Petroleum hydrocarbons / solvents and atrazine detected in GW above GCTLs at pesticide mix / load area and refueling area / runway within labor camp.	Excavated approximately 3,590 tons of soil from 5 areas within labor camp. Petroleum impacts in GW naturally attenuated below GCTLs. Source removal reduced atrazine GW concentrations below GCTL.	CSRCO, 7-21-06, Soil above SCTL, with Non-residential Deed Restriction
	Pump Station (T-6)	OCPs detected above SQAGs	20 soil samples collected around pump station; no OCPs detected above SQAGs of SCTLs	SRCO, 12-21-99
	Pump Station (T-7)	No soil or groundwater samples collected; Visual evidence of soil staining	14 surficial soil samples collected around pump station; no exceedances above SQAGs or SCTLs	SRCO, 12-21-99

Tract Nos.	Point Source RECs Identified in Phase I	Soil / GW Exceedances Identified in Phase II	Corrective Action Summary	Regulatory Concurrence
	Pump Station (T-8)	No soil or groundwater samples collected; No visual evidence of soil staining; Still included as Exclusion Area	Excavated approximately 6.36 tons of petroleum impacted soil	SRCO, 12-21-99
	Pump Station (T-24)	No soil or groundwater samples collected; No visual evidence of soil staining; Still included as Exclusion Area	Excavated approximately 0.68 tons of soil	SRCO, 12-29-99
	Pesticide Mix/Load Area (T-21)	Arsenic detected above SCTL and GCTL	Excavated approximately 692 tons of arsenic impacted soil. Installed GW pump and treat system, operated for 3 months, effectively lowered the arsenic concentrations below the GCTL	CSRCO, 7-21-06, Soil above SCTL, with Non-residential Deed Restriction

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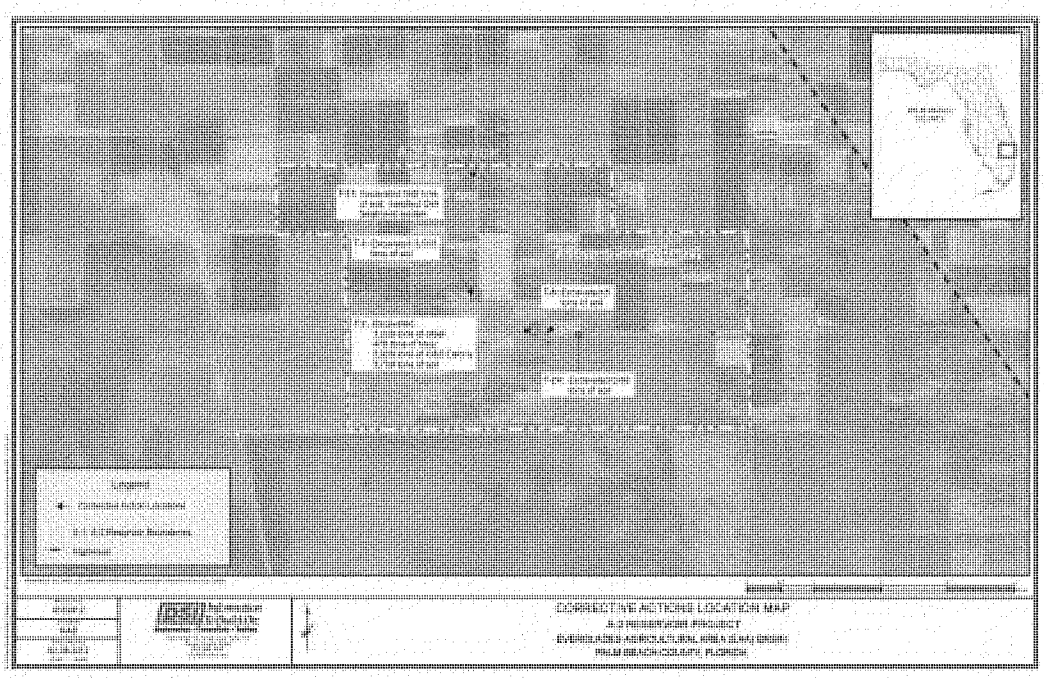


Figure C.1-15. Corrective Actions Map, A-2 Footprint (PSI INC. 2012)

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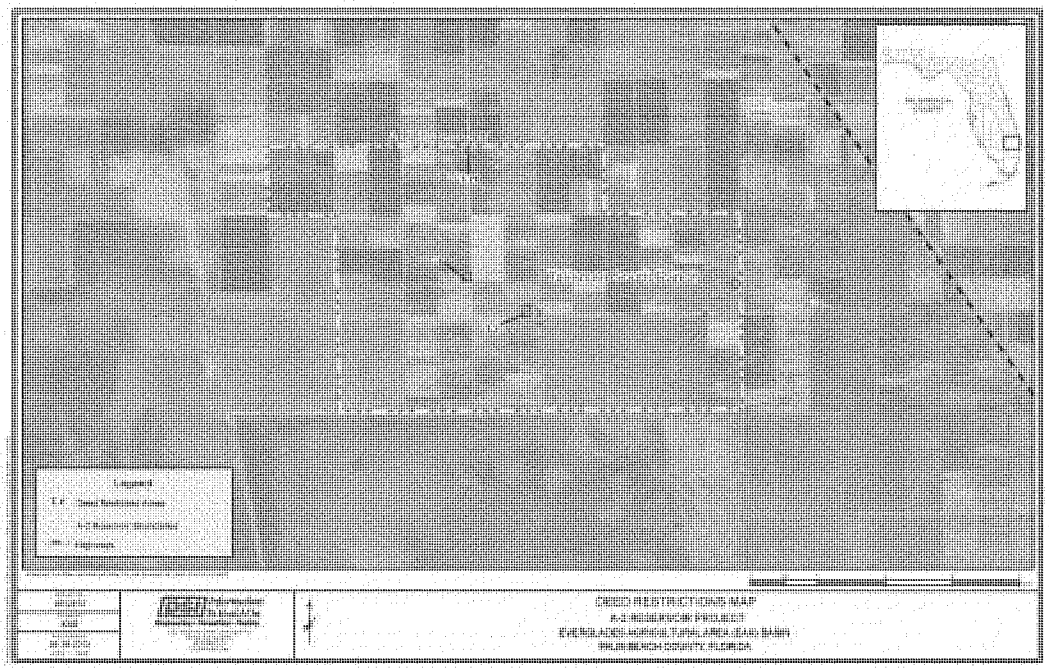


Figure C.1-16. Deed Restrictions Map A-2 Footprint (PSI INC. 2012)

Table C.1-6 shows a list of environmental audits conducted since 1998 on the A-2 lands. The environmental audits and correspondence between the SFWMD and the FDEP show that several HTRW sites have been found and remediated on the subject property. Four of the sites have SRCOs which means that no further action, monitoring, or prohibitions on future use are necessary. In August of 2012, the SFWMD prepared a draft summary report of the investigations and HTRW site remediation efforts on the property. This report recommended that soil samples be collected in the cultivated areas on the subject property to see if residual agricultural chemical concentrations exceeded any human health or environmental criteria applicable to the planned future land use (shallow reservoir). The Phase II Environmental Site Assessment Report and its addendum (PSI, 2013) found in **Annex H (Hazardous, Toxic and Radioactive Wastes)** is summarized below.

Table C.1-6. Summary of Environmental Reports, A-2 Flow Equalization Basin

Consultant	Report Type	Report Title	Report Date	Tract Nos.
URS/Dames & Moore	Phase I / II	Talisman Sugar Corp.- Vol. 1 - Acquisition Properties	November-98	100-104*
PSI	SRCR	Talisman Sugar Corp. - T-2 Borrow Pit	February-02	100-104*
PSI	Tank Closure Report	Talisman Sugar Corp. - Labor Camp (Abel's Flying Service	April-01	100-104*
PSI	SRCR	Talisman Sugar Corp. - T-3 (Labor Camp	March-03	100-104*
PSI	LCAR / NFA Request	Talisman Sugar Corp. - T-6 (Electric Pump Station)	August-99	100-104*
PSI	LCAR / NFA Request	Talisman Sugar Corp. - T-7 (Pump Station)	September-99	100-104*
PSI	SRCR	Talisman Sugar Corp. - T-8 (Pump Station)	September-99	100-104*
PSI	SRCR	Talisman Sugar Corp. - T-24 (Pump Station)	October-99	100-104*
PSI	SRCR	Talisman Sugar Corp. - T-21 Pesticide Mix/Load Area	May-02	100-104*
URS	Site Inspections/Environmental Assessment	Deferred Parcels - Former Talisman Property	July-07	100-104*
URS	Final Site Inspections/Environmental	Eight Deferred Parcels - Former Talisman Ranch Property	January-09	100-104*

Consultant	Report Type	Report Title	Report Date	Tract Nos.
	Assessment			
URS	Environmental Assessment Summary Document	Everglades Agricultural Area Basin Reservoir Project	March-03	--
PSI	Summary Environmental Report	Central Everglades Study, A-2 Reservoir, Palm Beach County FL	August 23, 2012	100-104*
PSI	Phase II Environmental Site Assessment	A-2 Flow Equalization Basin, Palm Beach County, FL	March 25, 2013	100-104*
PSI	Phase II Environmental Site Assessment, Addendum	A-2 Flow Equalization Basin, Palm Beach County, FL	May 3, 2013	100-104*
SRCR = Site Rehabilitation Completion Report				
LCAR = Limited Contamination Assessment Report				
* = Tract Nos. 100-149, 100-044, 100-047, 100-066, 100-067, 100-139, 100-141, 200-005, 100-143				

In January of 2013, the SFWMD's contractor, PSI, Inc., collected 30 samples from randomly selected 50 acre grids located on the A-2 FEB lands. The samples were analyzed for a comprehensive list of pesticides and the results of the analysis were compared against human health and ecological screening criteria.

Copper was detected in approximately 27% of the composite samples at concentrations exceeding the USFWS Interim Screening Level (ISL) of 85 mg/kg for the protection of the endangered snail kite. The detected copper concentrations ranged as high as 110 mg/kg and exhibited a normal data distribution with a mean concentration of 77.2 mg/kg and a 95% upper confidence limit (UCL) of 81.3 mg/kg. Spatially, the data present a random pattern, and no discernible areas of higher concentrations could be interpreted from the maps. PSI determined that based upon the relatively low level of exceeding 85 mg/kg copper and the high organic content of the soils which would tend to reduce the bioavailability of copper, that the risk to the endangered snail kite is minimal and that no remedial action to address copper was warranted.

PSI determined that arsenic concentrations across the majority of the A-2 FEB footprint are likely to exceed the FDEP Soil Cleanup Target Level for Residential Direct exposure, but the detected concentrations are all below the SQAG-TEC criterion. Arsenic concentrations are not likely to represent a human health or ecological risk, as long as the soil is managed on-site and is not disposed off-site at an uncontrolled site. The FDEP reviewed the arsenic data and recommended that a soil management plan be prepared as part of the construction plans to track the fate of arsenic impacted soils.

PSI detected a number of chemicals, including 2,4-D, atrazine, metribuzin, phorate, dieldrin, chromium, mercury, selenium, and silver in one of more of the composite soil samples at concentrations exceeding the soil cleanup target levels for leaching to surface water (SCTL-LSW). Follow up SPLP (Synthetic Precipitation Leachate Procedure) testing was performed to determine the potential for exceeding surface and groundwater quality criteria. An evaluation of the chemical data indicated that exceedances of the Class III surface water at the discharge of the A-2 FEB are very unlikely due to the following factors:

- A number of the chemicals such as 2, 4-D, atrazine, metribuzin, and phorate are relatively short-lived in the environment and were recently applied during active crop management. These chemicals are not likely to be present in the soil at significant concentrations once agricultural operations cease and the reservoir is constructed.
- Dieldrin is biologically persistent, but was only detected sporadically in the A-2 FEB footprint. The effect of dilution from incoming surface water and water overlying clean areas of the FEB are likely to dilute any leaching of these chemicals within these limited areas.
- Chromium, mercury, and selenium were consistently detected and silver was detected at a few locations at concentrations exceeding the SCTLLSW criteria. However, these metals all absorb strongly to organic matter in the soil and are not likely to leach to a significant degree from the highly organic soils in the A-2 FEB. Default SCTL-LSW criteria are based on soils with a much lower organic content than the soils on the subject property.

Overall, no evidence of elevated agrochemical contamination within the soils was found that would cause concern related to the construction of the A-2 FEB based on risk to the future aquatic community or to USFWS trust species that may utilize the future habitat provided by its construction. The USFWS and FDEP reviewed the PSI report, effectively concurred that no remedial action was warranted at this time, and recommended monitoring of copper and other contaminants during start up of the FEB. The Agricultural-Chemical section of the PIR (**Annex H**) addresses the findings of the cultivated soil sampling and how the USACE September 2011 Agricultural Chemical Policy for CERP projects applies.

C.1.1.15.2 Water Conservation Area 3A and 3B

The WCAs were created in 1945 by C&SF Flood Control District (predecessor to the SFWMD). These lands have been operated since 1945 for water supply, flood protection, and recreation and generally are inaccessible by terrestrial vehicles. Along the boundary of WCA 3A/B there are levees and canals constructed in the 1950s and 1960s that further limit vehicle access to the interior. Activity within the WCA is generally limited to fishing, hunting, and birding though there may be some illegal dumping of solid wastes along the perimeter. No soil testing for residual contaminants has been conducted within the WCA 3A/B as part of this project since the lands have no history of prior agricultural or industrial use that would cause such contamination.

There are 75 private hunting camps that are accessed primarily by boat. The Miccosukee Tribe of Indians of Florida uses leased land within the area for hunting and cultural activities. None of these activities are likely to result in significant HTRW contamination. Alligator Alley (Interstate 75) runs across the northern portion of WCA 3A. An abandoned crude oil pipeline runs east-to-west across WCA 3A from Immokalee to Port Everglades in Fort Lauderdale. The pipeline was installed in the 1960s. In 1986, a spill of approximately 6,000 gallons of crude oil occurred. This spill was cleaned up by collecting

free product and burning contaminated vegetation. The pipeline has not operated since 1986 and is considered to be abandoned.

During the 2nd World War, portions of WCA 3A and 3B were used as bombing ranges. Two bombing range sites are located within WCA 3A. Fort Lauderdale Bombing Target #1 is located on the L-68A canal approximately two miles south of Interstate 75. Evidence of bombing debris was found at this site during a phase I survey in 2005. Further investigation has not occurred to date because of the low probability that this site presents a human health risk given the isolated location. Fort Lauderdale Bombing Target #5 is located at the confluence of the L-68A and L-37 borrow canals. This site was investigated as part of the Formerly Used Defense Site (FUDS) program in 2005. No evidence of contamination was found during this survey and the site was closed for further investigation.

Table C.1-7 includes 14 sites within or in the vicinity of WCA 3A/B as identified from a database search of the FDEP Waste Cleanup record system performed in January 2013. Ten of the sites are listed as having petroleum contamination, while the remaining sites are listed as having other contaminants. Four of the sites are listed as pending and the remaining are listed as active. Six of the sites are roadway spills of petroleum product that occurred on Highway 27 or Interstate 75. Project features within these two highway right-of-ways are not contemplated as part of CEPP. Several of the identified locations are potentially adjacent to CEPP project features. Specifically, the petroleum cleanup site identified as "Everglades Safari" is located just south of Highway 41 (Tamiami Trail) very near the Blue Shanty Canal. The two HTRW sites identified as "Hadley Farms" are located at the northern boundary of WCA 3A and may be adjacent to CEPP hydrologic features yet to be sited and designed. Appropriate HTRW testing would be completed during the PED phase.

Canals and levees on the perimeter and interior of the WCAs have generally been constructed by excavating native soils that have not previously been used for agriculture. Given this history, sampling spoil mounds is not necessary during the planning phase of the project since the results would reflect concentrations that are at or near background conditions. It is possible that localized contamination might exist at locations where project features such as pump stations, levees, canals, and culverts will be built. Testing would be completed during the PED phase and remediation or resiting of features would occur as required.

Table C.1-7. Identified HTRW Sites within or Near WCA 3A and 3B per FDEP Waste Cleanup Database

SITE ID	CLEANUP CATEGORY	STATUS	BUSINESS NAME, ADDRESS	LATITUDE			LONGITUDE		
26368543	PETRO	ACTIVE	ABC TRANSPORT USA INC BER 10-2I-43871Z 6138 CLEAVLAND ST, MIAMI	26	19	24.7	80	31	45.7
26364823	OTHCU	PENDING	BIRD DRIVE TR 308-347 BRID DRIVE, MIAMI	25	43	8.584	80	28	13.563
26368154	PETRO	ACTIVE	EVERGLADES SAFARI 26700 SW 8TH ST, MIAMI	25	45	38.1924	80	37	33.0888
26364266	OTHCU	PENDING	FL CRYSTALS HADLEY FARMS PS H 1-1 SOUTH BAY	26	20	3.3481	80	36	43.9144
26364269	OTHCU	PENDING	FL CRYSTALS HADLEY FARMS PS H 1-2 SOUTH BAY	26	20	3.7139	80	35	45.6307
26376747	PETRO	PENDING	FL DEPT OF TRANSPORTATION US HWY 27, SOUTH BAY	26	20	16.74	80	32	27.06
26377945	PETRO	PENDING	FL DEPT OF TRANSPORTATION ROW US HWY 27, SOUTH BAY	26	20	10.22	80	32	21.17
26364107	OTHCU	PENDING	FLORIDA CRYSTALS FARM 21 & HADLEY FARM US HWY 27, SOUTH BAY	26	20	9.1597	80	37	43.2883
26377457	PETRO	PENDING	GENERAL PORTLAND-DADE CNTY PLT 5800 N KROME AVE, MIAMI	25	42	29.429	80	29	11.3536
26377413	PETRO	PENDING	PEMBROKE PINES CITY-HOLLY LAKE PUMP ST 21800 N 7TH MANOR, PEMBROKE PINES	26	0	51.8846	80	26	20.9125
26374606	PETRO	PENDING	SOUTH FL WATER MGMT DIST S-140 57005 ALLIGATOR ALLY, FORT LAUDERDALE	26	10	15.35	80	49	38.72
26378516	PETRO	PENDING	SOUTH FLORIDA TRUCK LINES SPILL-ALLIGATOR ALLEY I-75 150 YDS W OF E TOLL PLAZA, WESTON	26	8	45.4812	80	28	5.3904

SITE ID	CLEANUP CATEGORY	STATUS	BUSINESS NAME, ADDRESS	LATITUDE			LONGITUDE		
26367061	PETRO	ACTIVE	SSL CARGO EXPRESS 04-2I-0248 I-595 @ US 27 OFFRAMP, WESTON	26	8	35.2434	80	26	20.4174
26369543	PETRO	ACTIVE	T STOP SERVICES INC 4690 US HWY 27, FT LAUDERDALE	26	3	47.5347	80	25	58.4817

C.1.1.15.3 Northern Everglades National Park

The CEPP project alternatives under consideration in this PIR include construction of project features along the L-29 and the L-31N canal/levee corridors as well as along the L-67 extension levee. Highway 41 (Tamiami Trail) runs just south of the L-29 Levee/Canal and the northern ENP boundary is south of the highway. The L-29 levee was constructed in 1928 using native soils and limerock excavated from the adjacent borrow canal. The "Everglades Safari" petroleum spill site, the Bird Drive Basin HTRW site, and the General Portland site listed in **Table C.1-7** are adjacent to the northeastern boundary of ENP.

Given that the road and levee were constructed across an area that was undeveloped in 1928, the levee spoil material is considered to be free of anthropogenic contamination with the exception of isolated undiscovered spill sites. However, during construction of the first Tamiami Bridge just south of the eastern portion of WCA 3B, some of the topsoil within the highway right-of-way was determined to have elevated arsenic concentrations that are likely representative of background concentrations.

C.1.1.16 Cultural Resources

A review of the Florida State archives indicate that there are 23,499 recorded cultural resource sites and resource groups within the CEPP study area that have a survey determination and/or State of Florida Historic Preservation Office (SHPO) evaluation of other than ineligible for listing with the National Register of Historic Places, or significant under the National Environmental Policy Act (NEPA). The area of potential effect (APE) on cultural resources for the project is markedly smaller than the CEPP study area. The APE is approximately 1.5 million acres being comprised of the EAA A-2 footprint, portions of the L-6 levee and associated canal, the L-5 levee and associated canal, the L-4 levee and associated canal, the S-8 Pump Station Complex, the L-28 Triangle, portions of the Seminole Tribe of Florida's Big Cypress Reservation immediately west of L-28 and north of I-75, portions of the Miami Canal, WCA 3A and 3B, L-67A and L-67C levee and associated canal, portions of the L-29 levee, the L-67 Ext levee and associated canal, portions of the Old Tamiami Trail, and portions of the L-31N levee, and Everglades National Park. For more information on existing project conditions for cultural resources, refer to **Section 2**.

All lands within WCA 3 and EAA A-2 are state owned and/or managed, therefore land management responsibilities including cultural resources within those lands should be conducted as described in F.S. 267.061(2) and management plans developed in consultation with the Florida Division of Historic Resources. See Appendix G in "A Conceptual Management Plan for The Everglades Complex of Wildlife Management Areas" at http://myfwc.com/conservation/terrestrial/management-plans/online-mps/. Cultural Resources within National Park Service Lands will be managed in accordance to Federal laws and pre-established management plans for resources under National Park Service jurisdiction.

A total of 43 cultural resources surveys and/or assessments have been conducted within the CEPP APE, 14 of which included structural surveys. **Table C.1-8** below lists all currently known cultural resources within the CEPP APE that are or have the potential to be significant under NEPA.

Table C.1-8. Significant Cultural Resources within the CEPP Area of Potential Effect

	Significant	Unknown Significance*	Date Range	Notes
Archeological Sites	47	296	2500 B.C – A.D. 1950	73 remote sensing sites**
Structures	1	5	A.D. 1947–1958	
Historical Districts	5	0	2500 B.C – A.D. 1950	All NRHP Listed
Linear Resources***	12	13	A.D. 1880 – 1950	1 HRHP Listed
Traditional Cultural Properties	2	0	A.D. 1950 –present	Associated with the Modern Gladesman
World Heritage Site	1	0	-	Everglades National Park
Culturally Significant Sites	34			

*SHPO determination listed as: Not Evaluated by SHPO or Insufficient Information.

** Sites recorded using aerial photography. Presence or absence of material has not been field verified.

***Canals, roadways, or linear earthworks.

The earliest known habitation sites within the CEPP APE date to the Late Archaic period (2,500 B.C.) when the Everglades were much drier. However, within the larger area of south Florida, evidence of Paleo-Indian (12,000 to 7500 B.C.) habitation has also been recorded (i.e. Warm Mineral Springs (8SO18) and Little Salt Spring (8SO79). Some of the Late Archaic habitation sites have only recently been rediscovered as the result of managed drainage programs in south Florida.

As the climate warmed and sea level rose, many Native Americans abandoned the lowest of the tree islands as they became submerged. This process continued through what is known as the Middle Archaic, until climate conditions stabilized around 300 B.C. at the start of the Late Archaic. Today many sites from both the Early and Middle Archaic periods are no longer submerged and may have more modern Native American use (Milanich 1994).

After the Archaic period, the region became incorporated into what is known as the Glades region and remained inhabited until European contact, when Old World diseases and slave raiding heavily reduced the Native populations during the late 1500s-1700s. Many of the tree islands through this portion of the CEPP APE have sites associated to the Glades period. This period has been broken down into successive stages starting with Glades I, which dates from 500 B.C .to 750 A.D., Glades Period II dating from 750 to 1200 A.D., and Glades Period III dating from 1200 A.D. to European contact in the 1500s. Typical habitation sites through this region are commonly referred to as middens, which are the accumulation of daily life activities on these tree islands. Material remains can stretch from the surface to well over one meter below the surface on certain islands. Native American burials can also be found among these habitation sites (Milanich 1994).

After European contact, Native American populations in the region continuously declined and remained at low levels until groups relocated into southern Florida while fleeing the U.S. Army and U.S. Governments' forced relocation program. Today, many sites associated with the Miccosukee Tribe of Indians of Florida and Seminole Tribe of Florida are known to exist throughout the region. Refer to **Section 2.6** and **Appendix C.1.2** for more information.

C.1.1.17 Socioeconomics

Florida's economy is characterized by strong wholesale and retail trade, government, and service sectors. The 2010 population estimates for each of the LEC Planning Area counties are as follows: Palm Beach County (1,340,134 residents), Broward County (1,748,066 residents), and Miami-Dade County (2,496,435 residents). The economy of south Florida is based on services, agriculture, and tourism. Florida's warm weather and extensive coastline attract vacationers and other visitors and help make the state a significant retirement destination. The three counties that comprise the LEC (Palm Beach, Broward, and Dade) are heavily populated, and it is estimated that over 6.9 million people will reside in this region by the year 2050. A complete socioeconomic description of the C&SF Project area was completed in the Comprehensive Review Study (USACE 1999) and is incorporated into this document by reference. The Okeechobee Intercoastal Waterway (OIWW) provides economically and politically important commerce between the eastern and western coasts of Florida. The waterway connects the Atlantic Intracoastal Waterway to the Gulf Intracoastal Waterway and is a congressionally authorized project, with depths and operations required for efficient navigation on the system. The authorized C&SF project depths for Lake Okeechobee navigation are based on 12.56 feet NGVD.

C.1.1.18 Study Area Land Use

The existing land use within the study area varies widely from agricultural to high-density multi-family and industrial urban uses. Much of the land use/cover change occurring in south Florida over the past several years can be categorized as either the creation of new developments in previously natural or agricultural areas, or the change in the types of agriculture practiced. Much of the land used for agriculture is likely categorized as unique farmland based upon its location, growing season, and high value crops.

An estimated 742,668 acres of irrigated agricultural lands are located in the Lake Okeechobee Service Area (LOSA). Agricultural lands adjacent to the St. Lucie River and Indian River Lagoon and Caloosahatchee River and Estuary are cultivated for citrus, sugarcane, vegetables, sod, and greenhouse/nursery. Growth in citrus acreage is usually on land that was formerly pastureland. Vegetable crops include cucumbers, peppers, tomatoes, squash, eggplant, watermelons, snap beans, and potatoes. Wetlands, uplands, and urban uses comprise the remaining land area within LOSA and Northern Estuaries.

An estimated 447,000 acres of agricultural lands are located in the EAA. Currently, land in the EAA is primarily in agricultural production, with sugarcane being the primary crop. There are six sugar mills and one refinery (South Bay) currently operating in the EAA, with an additional mill and refinery in Clewiston also serving the area. The combined capacity of these mills is over 17 million tons. Three major entities - U.S. Sugar Corporation, Florida Crystals Corporation, and Sugarcane Growers Cooperative - provide the majority of the sugarcane production in the EAA. Secondary agricultural uses include vegetables, rice, sod, and improved pasture. Wetlands, uplands, urban and extractive uses comprise the remaining land area within the EAA.

Generally, urban development is concentrated along the LEC from Palm Beach County to Dade County (**Figure C.1-17**). The LEC extends approximately 100 miles through the coastal portions of Palm Beach, Broward, and Dade Counties. As the most densely populated sub-region in the state, the LEC is home to one-third of the state's population, more than 4.5 million people. The sub-region is primarily an urban megalopolis, but it also contains substantial agricultural acreage, particularly in southwestern Dade County (90,000 acres). Rapid population growth and land development practices have resulted in notable western urban sprawl; the predominant land use is single-family residential. The once

significant rural population in the western areas of Broward County has practically disappeared, resulting in an urbanized makeup in population.

A large portion of south Florida remains natural, although much of it is disturbed land. The dominant natural features within the study area include two major management areas located south of Lake Okeechobee. These include the Everglades Complex of Wildlife Management Areas (ECWMA) and ENP. The ECWMA includes three adjacent Wildlife Management Areas (WMAs). These include the: (1) Rotenberger WMA, (2) Holey Land WMA, and (3) Everglades (WCA 3A) and Francis S. Taylor (WCA 3B) WMAs. The ECWMA is described in the next section. The Rotenberger and Holey Land WMAs are located north of WCA 3A and south of Lake Okeechobee between the Miami and North New River Canals.

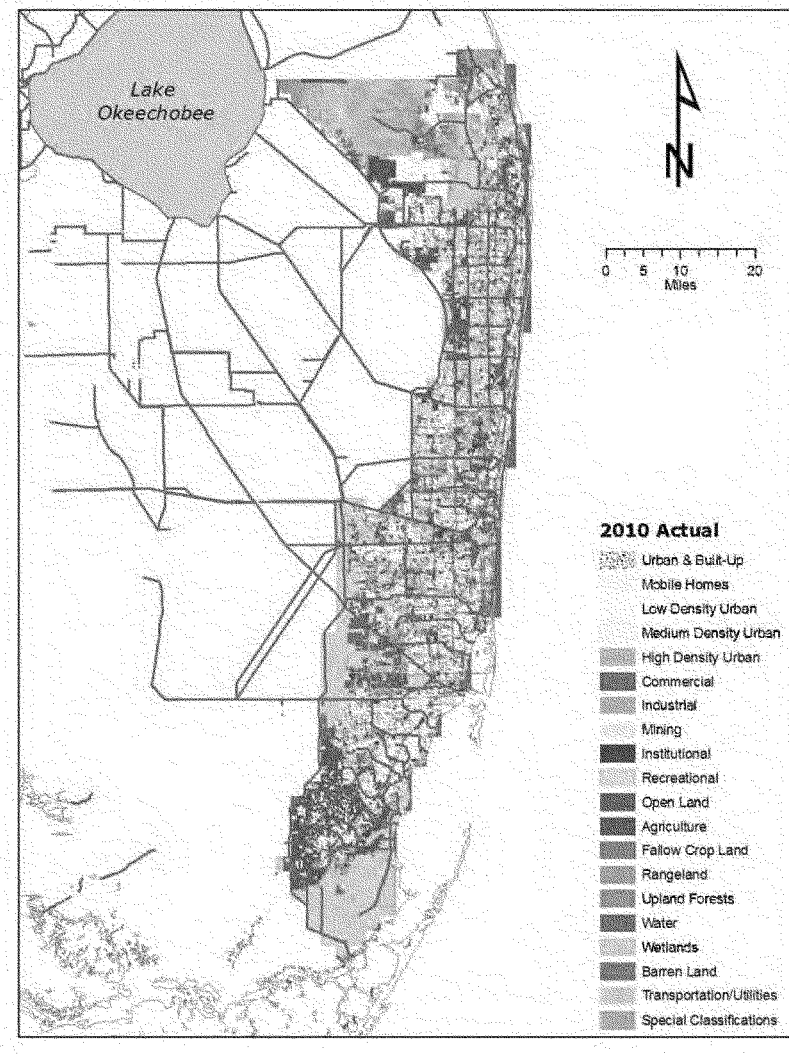


Figure C.1-17. Study Area Land Use (2010)

C.1.1.19 Public Land Management

Lands in the ECWMA are managed by the FWC under 2 leases from the State of Florida and through a 1952 cooperative management agreement with the SFWMD. An agreement was also formed among the State of Florida, the FWC, the SFWMD, and the Miccosukee Tribe of Indians of Florida in 1982 granting a perpetual lease to the Miccosukee Tribe of Indians of Florida for approximately 189,000 acres of WCA 3A.

The FWC has outlined a conceptual management plan for the ECWMA (FWC 2007) providing general information on resource management goals and objectives. Management activities within the ECWMA include the maintenance and restoration of plant and animal communities, public education, recreation, and habitat protection. Management emphases by the FWC consists of the development and recommendation of water regulation schedules to address hydrological restoration, improvement of the quality of existing habitats to benefit native fish and wildlife species through prescribed burns, control of exotic species, and plantings of native trees and shrubs. Recreational hunting is used as the primary management tool to maintain resident game populations in the ECWMA. The FWC also manages the sport fishery within the ECWMA by providing regulations pertaining to size and possession limits. The FWC also coordinates with cooperating agencies to maintain access to the canal system and public use areas to maximize boat and bank fishing opportunities.

ENP spans nearly 1.5 million acres of wetlands, uplands, and submerged lands at the southern end of the Florida peninsula. ENP, authorized by Congress in 1934 and established in 1947, was established to protect the unique tropical biological resources of the southern Everglades system. It was the first national park to be established to preserve purely biological (versus geological) resources. The Park's authorizing legislation mandated that it be managed as "wilderness, [where] no development ... or plan for the entertainment of visitors shall be undertaken which will interfere with the preservation intact of the unique flora and fauna and the essential primitive natural condition now prevailing in this area." This mandate to preserve wilderness is one of the strongest in the legislative history of the National Park System. ENP has been designated a World Heritage Site, an International Biosphere Reserve, and a Wetland of National Significance. In addition, 86 % of ENP is designated wilderness under the Wilderness Act of 1964. ENP is managed by the NPS.

C.1.1.20 Recreation

There are many recreational opportunities throughout south Florida; however, with the dense urban surroundings demand often exceeds availability. Recreational resources in the Lake Okeechobee region are primarily water based. Lake Okeechobee and the Okeechobee Waterway provide approximately 154 miles of navigable waterway for commercial navigation and many more for recreational boating. Lake Okeechobee is recognized as supporting one of the best recreational fisheries in the nation. Several major sport fishing tournaments are held on the lake annually, bringing significant revenues to the surrounding area. Recreational areas are located around Lake Okeechobee offering day-use facilities, campgrounds, hiking and biking trails, and boat ramps. The Lake Okeechobee Scenic Trail (LOST) is designated as a segment of the Florida National Scenic Trail, encompassing 110 miles of the lake atop Herbert Hoover Dike (HHD). Heavy seasonal waterfowl utilization of Lake Okeechobee attracts hunters and recreational enthusiasts, as well. Lake Okeechobee has also been a popular destination for airboat rides.

Recreation opportunities in the Northern Estuaries include easy access to fresh, estuarine, and marine resources for fishing, boating, swimming, diving, camping, and sightseeing. Numerous recreation areas,

such as the Ortona Lock Recreation Area, Caloosahatchee Regional Park, and W.P. Franklin Lock Recreational Area are extensively used.
STAs provide recreational opportunities within and adjacent to the EAA. Passive recreational use includes bicycling, hiking, nature photography, wildlife viewing, and fishing. Waterfowl and alligator hunting are also permitted in some STAs.

Recreational opportunities are also present within the Greater Everglades. Rotenberger and Holey Land WMAs are open to public access year round. Primary recreational opportunities include hunting, fishing, camping, hiking, and bicycling. Game species occurring in the WMAs include white-tailed deer, common snipe (*Gallinago gallinago*), feral hog (*Sus scrofa*), marsh rabbit (*Sylvilagus palustris*), blue-winged teal (*Anas discors*), mottled ducks (*Anas fulvigula*), and other game. Alligator hunting is also currently administered on Holey Land WMA. The Everglades (WCA 3A) and Francis S. Taylor (WCA 3B) WMA lands have been used for recreational activities including hunting, fishing, frogging, boating, camping, and off-road vehicle use. Fishing is a popular recreational activity and also holds numerous tournaments each year. The majority of fishing activity occurs in the canals along Interstate75, Highway 41 (Tamiami Trail), and in the Miami, L-67 A, and L-67 C canals. These canals support many species of game fish. Private camps are located throughout WCA 3. These permitted camps are primarily used as weekend retreats and hunting camps. A variety of other nature-based recreational opportunities are also provided to the public within WCA 3A and WCA 3B. These activities include wildlife viewing and nature photography. Hiking and bicycling are also permitted on existing levees within the project area where appropriate. Though hiking and bicycling opportunities are available they lack sufficient facilities and markers. There are also several recreation areas at locations along the boundary of WCA 3 including the Sawgrass Recreation Area, Everglades Holiday Park, Thompson Park and Mac's Fish Camp. These facilities, along with several on Highway 41 (Tamiami Trail), provide boat ramps, camping facilities, boat rentals, airboat tours, fishing guides, bait and tackle supplies, and food. Some of these areas are privately owned, while others are public properties leased to private providers of services.

Similar recreational opportunities are provided in ENP. ENP provides high-quality fishing, boating, camping, wildlife viewing, hiking, bicycling, and nature interpretation activities. One third of ENP is covered by water, creating excellent boating and fishing opportunities. Saltwater fishing includes Florida Bay, Ten Thousand Islands, and elsewhere in the park's coastal zone. Marinas and boat ramps are located throughout the park. Day use and camping (front and back country) facilities are also available. There are also a number of elevated camping platforms (chickees) available in various locations throughout the Park. Regularly scheduled concession or ranger guided tours are also available.

The State Comprehensive Outdoor Recreation Plan (SCORP) is the best source of information on recreation demand and supply at the state and regional scales. It divides the state into 11 planning regions, each with clusters of counties. As indicated in **Table C.1-9**, Treasure Coast and south Florida are the planning regions that encompass the study area.

Table C.1-9. Counties within SCORP Planning Regions

Region	Counties
Treasure Coast	Brevard, St. Lucie, Martin, Palm Beach
South Florida	Broward, Miami-Dade, Monroe

The SCORP organizes outdoor recreation in Florida into 47 categories that encompass a variety of recreation activities including team sports (e.g., basketball and baseball), individual sports (e.g., golf

and tennis), hunting, fishing, swimming and boating. **Table C.1-10** presents descriptive information on the recreation facilities in SCORP Regions for study area specific recreation categories. These resource-based categories were selected as those that could potentially be affected by the hydrologic changes or ecological changes associated with the alternative restoration plans. This table includes percentages of the statewide totals for the recreation categories.

Table C.1-10. Regional Outdoor Recreation Facilities 2007

Resource / Facility	Treasure Coast	South Florida	State Total
Outdoor Recreation Areas	1,314	2,054	13,235
Outdoor Recreation Acres	748,130	3,146,974	13,352,957
Land Acres	665,617	1,796,151	9,671,238
Water Acres	76,339	1,350,609	3,673,955
Hunting Acres	343,366	698,451	5,290,496
Camping			
RV / Trailer Camp Sites	7,071	12,207	162,041
Tent Camp Sites	804	1,290	20,044
Trails			
Hiking Trails (miles)	392	420	5,424
Horseback Riding Trails (miles)	163	139	2,361
Nature Trails (miles)	117	254	2,475
Freshwater Catwalks	33	45	834
Boating			
Canoe Trails (miles)	65	292	2,295
Freshwater Boat Ramp Lanes	80	110	1,739
Freshwater Marinas	22	7	457
Freshwater Slips / Moorings	937	325	11,762

C.1.1.21 Noise

Noise levels are associated with surrounding land use. Within the major natural areas of south Florida, external sources of noise are limited and of low occurrence. There is no significant noise generating land users within these areas. Existing sources of noise are limited to the vehicular traffic travelling on roads adjacent to and cutting through the project area. Other sources of noise which may occur within these natural areas include air boats, off road vehicles, swamp buggies, motor boats, and occasional air traffic. Sound levels are typically in the range of 85 to 105 decibels (dB) for motorboats and air boats, respectively. Wilderness ambient sound levels are typically in the range of 35 dB and should not be an issue for wildlife.

Rural areas have typical noise levels in the range of 35 to 55 dB. Sources of noise in rural, areas include noise associated with agricultural production such as the processing and transportation of agricultural produce. The use of farm equipment such as tractors, plows, and the use of irrigation facilities would be expected to be the dominant background noise.

Within the rural municipalities and urban areas, sound levels would be expected to be of greater intensity, frequency, and duration. Noise associated with transportation arteries, such as highways, railroads, primary and secondary roads, airports etc., inherent in areas of higher population would be significant and probably override those sounds associated with natural emissions. Other sources of noise might be expected to include noise from everyday social and human communication and activity, operations of construction and landscaping equipment, and operations at commercial and industrial facilities. In general, urban emissions would not be expected to exceed 60 dB, but may attain 90 dB or greater in busier urban areas or near to frequently used high volume transportation arteries.

C.1.1.22 Aesthetics

The visual characteristics of south Florida can be described according to the three dominant land use categories: natural areas, agricultural lands, and urban areas. The natural areas consist of a variety of upland and wetland ecosystems, including lakes, ponds, vast expanses of marsh and wet prairie, with varying vegetative components. Uplands are often dominated by pine, although other sub-tropical and tropical hardwoods such as fig, gumbo limbo, and cypress do occur. These areas are more fully described in **Section C.1.1.1**. Overall, the land is extremely flat, with few natural topographic features such as hills or other undulations. Much of the visible topographic features within the natural areas are man-made, including canals and levees. Additional man-made features include pump stations, navigation locks, secondary and primary roads, highways, electrical wires, communication towers, occasional buildings, borrow pits and other features which may or may not detract from the regional aesthetic. Visual aesthetics when possible from a high perspective such atop a levee, offer pleasant and unspoiled perspectives of Everglades marsh with numerous birds and other wildlife. Agricultural lands are cultivated for citrus, sugarcane, vegetables, sod, and greenhouse/nursery. Generally, urban development is concentrated along the LEC from Palm Beach County to Dade County. Major cities are visually congested with residential communities, major transportation arteries (i.e. heavily used roads and highways), and intensively developed commercial and industrial facilities. Visual aesthetics are marginal. Development is typically immediately adjacent to or nearby protected natural areas. These areas are more fully described in **Section C.1.1.18** .

C.1.2 EXISTING CONDITIONS OF NATIVE AMERICANS

Unless otherwise referenced, the information below is a summary compiled from the Seminole Tribe of Florida website http://www.semtribe.com/History/ and from the Ah-Tah-Thi-Ki website http://www.ahtahthiki.com/History-Seminole-Tribe-FL-Ah-Tah-Thi-Ki-Museum.html

Refer to Section 2.6 for additional information. The tribes known today as the Seminole Tribe of Florida and Miccosukee Tribe of Indians of Florida are both descendents of the Muscogee Creek people, a diverse confederation that encompassed people speaking seven languages and spread over much of the southeast. Between 1740 and 1812, early Creek villages were established in northern Florida in the mission provinces of Apalachee and Timucua, around Tallahassee and Gainesville, and along the Apalachicola and Lower Suwannee rivers. Other Indian groups also migrated into Florida, including the Yuchi and Tamasee Indians, as well as Hitchity, Mikasuki, Choctaw, and Oconee. From 1812-1820, pressures in Alabama and Georgia encouraged Upper and Lower Creeks to migrate to Florida (Covington 1993:5 and Milanich et. al, 2011). These Seminoles, as they all came to be known, (possibly a derivation of the Spanish cimarron, meaning runaway) were primarily seeking a solitary place to subsistence farm and raise cattle.

Beginning with the War of 1812 and ending with the Third Seminole War in 1858, the native people in Florida were subjected to an intensive effort by the U. S. Government to eradicate or remove them from

the region. The U.S. Government reportedly spent more than $20 million on this effort and sent more than 52,000 troops to fight fewer than 2,000 Seminoles in Florida. At the end of these efforts, most of the southeastern tribes were removed west to Indian Territory and fewer than 300 Seminoles survived in the Everglades. Their descendants make up the populations of both tribes today.

The remaining native people lived a subsistence existence in the Florida Everglades for the next century. Again encroachment from white settlers by the early 1900s forced them approach the Secretary of the Interior to request reservation lands. This request for Federal reservations and other services led to the split between the Seminole Tribe of Florida and the Miccosukee Tribe of Indians of Florida. The Miccosukee Tribe of Indians of Florida, who spoke Hitchiti and lived primarily along Tamiami Trail, objected to the acceptance of Federal monies and services in exchange for land. Despite their objections, they were removed from ENP and confined to the Reserved Area, a narrow strip of land along Tamiami Trail. Although additional lands were designated and compensation money was paid to the tribe by the U.S., the money remains unclaimed by the tribe to this day.

In the 1950s when many tribes were facing the Indian Termination Act, the Seminole Tribe of Florida again had to fight the government for Federal recognition and services to continue their existence. The Miccosukee Tribe of Indians of Florida instead sought and received recognition as a sovereign nation from Fidel Castro and Cuba, forcing the U.S. Government to recognize them.

During this time, both tribes lived in relative poverty, continuing their subsistence lifestyle in the Everglades, and relying on the tourist trade to supplement their incomes. In 1979, the Seminole Tribe of Florida established the first high stakes bingo operation in the nation. The passage of the Indian Gaming Rights Act in 1988 allowed them to expand into other high stakes gambling, and both tribes have financially prospered as a result.

Today most Tribal members live within the confines of their reservations located in south Florida (**Figure C.1-18**). Red coloration depicts reservation and leased lands by the Miccosukee Tribe of Indians of Florida. Yellow coloration depicts reservation and leased lands by the Seminole Tribe of Florida.

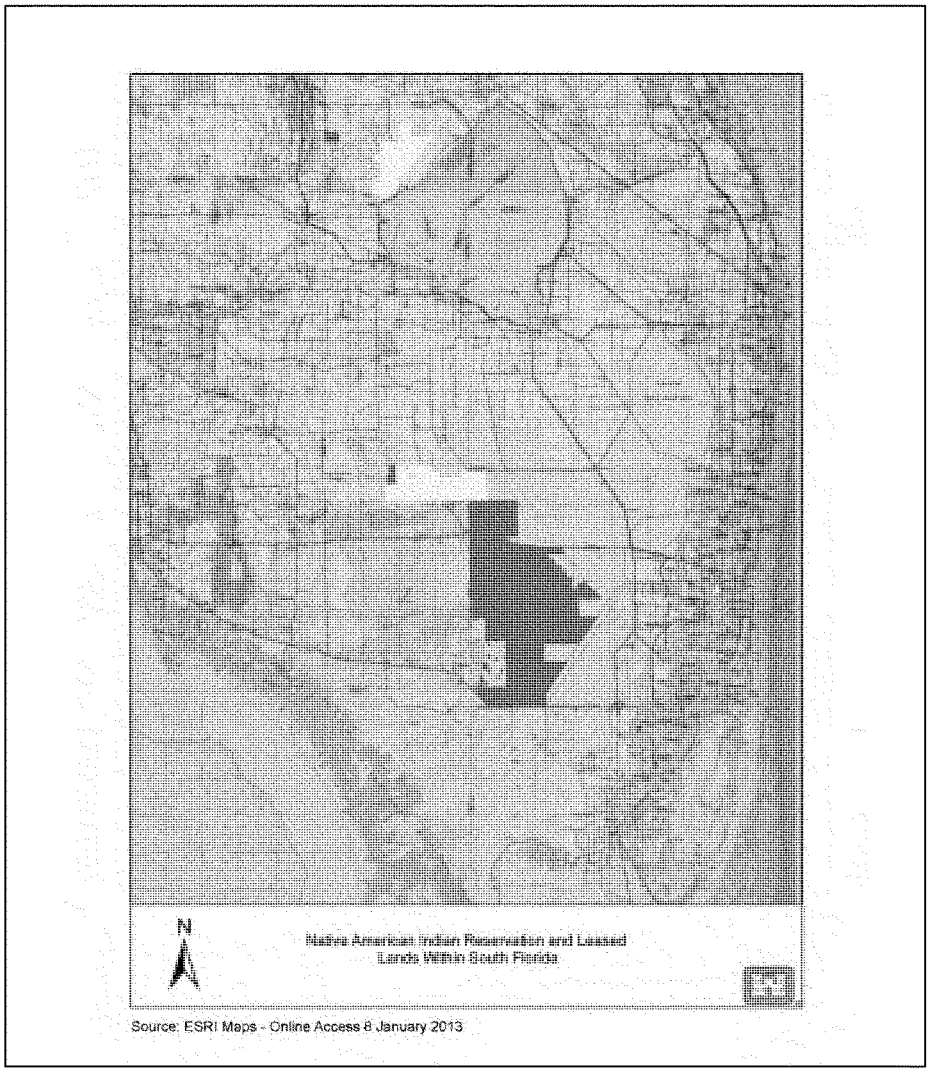


Figure C.1-18. Map Outlining the Location of the Tribal Reservations and Leased Lands

C.1.3 FUTURE WITHOUT PROJECT CONDITIONS OF RESOURCES

The future without project (FWO) condition is the projection and forecast of what is "most likely" to occur in the study area over the planning horizon. The FWO project condition for CEPP assumes the construction and implementation of authorized CERP and non-CERP projects, and other Federal, state or

local projects constructed or approved under existing governmental authorities that occur in the CEPP study area. Under NEPA the **No Action Alternative** needs to be evaluated, and for consistency of the report the **No Action Alternative** is referred to as the **Future Without [FWO]** for the remainder of the report. Construction has begun on the first generation of CERP project modifications already authorized by Congress. These include the Indian River Lagoon (IRL-S) Project (USACE 2004a), the Picayune Strand Restoration Project (USACE 2004b), and the Site 1 Impoundment Project (USACE 2006b). Second generation of CERP projects, authorized in WRRDA 2014, includes the Biscayne Bay Coastal Wetlands (BBCW) Project (USACE 2012b), Broward County Water Preserve Areas (WPA) Project (USACE 2012c), the Caloosahatchee River (C-43) West Basin Storage Reservoir (USACE 2010), and the C-111 Spreader Canal Western Project (USACE 2011). Non-CERP projects included within the FWO project assumptions consist of the SFWMD Restoration Strategies (SFWMD 2012c), C&SF Canal-51 West End Flood Control Project (USACE 1998), the C-111 South Dade Project, the Kissimmee River Restoration Project (USACE 1991), Modified Water Deliveries (MWD) to ENP Project (USACE 2000), and the DOI Tamiami Trail Modifications Next Steps (TTNS) Project (DOI 2010). **Table C.1-1** summarizes the status of non-CERP projects, CERP projects and operational plans assumed to differ between the existing conditions or FWO project assumptions and are incorporated below by reference unless otherwise noted. The following describes the projected physical, ecological, and socioeconomic conditions within the study area in the year 2072. The FWO project conditions are also summarized in **Section 2.0** of the main report. Refer to **Sections 2.5.1** through **2.5.15** for further information on how project features in **Table C.1-11** were represented in the hydrologic model simulation of the CEPP FWO baseline, where applicable.

Table C.1-11. Status of Non-CERP Projects, CERP Projects, and Operating Plan for Existing and Future Without Project Assumptions

CATEGORY	EXISTING CONDITION	FUTURE WITHOUT PROJECT CONDITION
Status of Non-CERP Projects	Modified Water Deliveries to ENP Project (MWD) features, including the S-355A and S-355B gated spillways, 4-mile degrade of L-67 Extension Levee, 8.5 Square Mile Area Flood Mitigation Project have been constructed and are operational.	Construction completed and features operated: C-111 South Dade (Contracts 8 and 9); C&SF C-51 West End Flood Control Project; Kissimmee River Restoration; SFWMD Restoration Strategies (Central Flow Path features); DOI TTNS Project (5.5 miles of additional bridges); Seepage Barrier Near the L-31 N Levee (Miami-Dade Limestone Products Association) MWD Project features including existing condition components plus Tamiami Trail Modifications (1-mile eastern bridge) are constructed. However no operational changes for the L-29 Canal stage, G-3273 constraint, or the S-356 pump station were represented in the CEPP FWO project condition.
Status of CERP Projects	No completed projects. Construction in progress.	Construction completed and features operated: IRL-S Project; Picayune Strand Restoration Project; Site 1 Impoundment Project; BBCW Project; Broward County WPA Project; Caloosahatchee River (C-43) West Basin Storage Reservoir; C-111 Spreader Canal Western Project.
Operations Plan for WCA 3A, ENP and the SDCS	Interim Operational Plan (IOP) (2002, 2006); L-29 Canal maximum operational stage limit: 7.5 ft National Geodetic Vertical Datum (NGVD); G-3273 constraint: 6.8 ft NGVD	ERTP (2012); L-29 Canal maximum operational stage limit: 7.5 ft NGVD; G-3273 constraint: 6.8 ft NGVD

C.1.3.1 Vegetative Communities

C.1.3.1.1 Lake Okeechobee

The majority of the surface of Lake Okeechobee is not vegetated and currently provides open (pelagic) habitat. Littoral vegetation occurs along much of Lake Okeechobee's perimeter, but is most extensive along the southern and western borders. The continued use of Lake Okeechobee to store water for agricultural and flood control needs would continue to result in high water levels within the lake. High water levels within the lake would continue to adversely affect shallow littoral zone habitat, and deeper littoral zones would remain without vegetation. In addition, even with state BMP's and other projects to improve water quality within the watershed, due to legacy effects, it is anticipated that the continued storage of nutrient-rich waters would maintain reduced water clarity that in turn adversely affects SAV areas. Vegetative communities in Lake Okeechobee are not expected to change significantly from existing conditions unless the regulation schedule is updated.

C.1.3.1.2 Everglades Agricultural Area

Habitat types within the EAA are divided into five general groups: aquatic, wetland, upland, disturbed (mostly agricultural), and urban/extractive. Changes to the remnant natural communities on lands within the EAA are dependent upon the overall agricultural use of the region and resultant water management. The aquatic communities within the EAA include both natural and man-made areas of open water. With continued use of the EAA region for agriculture during the period between the present and 2072, with the exception of land utilized for the SFWMD Restoration Strategies water quality treatment implementation plan (SFWMD 2012b), no significant net increase or decrease in aquatic areas within the EAA should occur. For remnant wetlands, continued subsidence of lands surrounding existing, small isolated wetlands could slightly increase the extent of wetlands into formerly cultivated lands. Larger scale changes in wetland cover could occur if agriculture is abandoned in some portions of the EAA. Cessation of active drainage of the agricultural fields would likely cause the fallow lands to revert to wetlands. Similarly, upland community margins could change to transitional wetlands if the surrounding landscape becomes wetter. Disturbed communities consist of mostly agricultural lands. Shifts between specific agricultural cover types may occur during the period between the present and 2072. Most of the urban / extractive lands are concentrated around the Belle Glade area; increases in urban and extractive cover types may occur near existing population centers due to increased urbanization. Vegetative communities in the EAA are not expected to change significantly from existing conditions.

All of Compartment A of the Talisman Land Exchange property is considered to be atypical jurisdictional wetlands based on hydric soils and hydrology. The SFWMD Restoration Strategies water quality treatment implementation plan will be fully in place by 2072 (SFWMD 2012b). Compartment A would be converted to a FEB, known as the A-1 FEB. Wetland vegetation would be expected to become established within the A-1 FEB. Vegetative communities currently existing in the A-2 area would remain. A-2 would remain in State ownership and would continue in agricultural and open space uses.

C.1.3.1.3 Northern Estuaries

The SAV is one of the most important vegetation communities of the Caloosahatchee River and Estuary and St. Lucie River and Estuary (including the Indian River Lagoon). Currently, SAV beds have been reduced or eliminated from their former areas by extreme salinity fluctuations, increased turbidity, sedimentation, dredging, damage from boats, and nutrient enrichment which causes algal blooms that, in turn, restrict light penetration. Continued flood control regulatory freshwater releases from Lake Okeechobee to the Northern Estuaries would continue to cause salinities to drop below preferred

ranges for estuarine biota. High-level freshwater discharges during the wet-season would continue to result in increases in nutrient inflows and turbidity to the estuaries, thereby adversely affecting sea grasses. Some level of improvement is expected to occur during the period between the present and 2072 as a result of implementation of projects within the study area with the capability of improving the timing, quantity, and quality of freshwater flow to the Northern Estuaries. Improvements in water quality and salinity levels within the estuaries as a result of the C-43 West Basin Storage Reservoir Project (USACE 2010) and Indian River Lagoon South Project (USACE 2004a) would reduce stress to SAV and aid in long term health of estuarine habitat and biota.

C.1.3.1.4 Greater Everglades

The Everglades landscape is dominated by a complex mosaic of freshwater wetland communities that includes open water sloughs and marshes, dense grass and sedge dominated marshes, forested islands, and wet marl prairies. The Everglades freshwater wetlands eventually grade into intertidal mangrove wetlands and sub tidal sea grass beds in the estuarine waters of Florida Bay. Changes in the availability and distribution of freshwater and further disruption of natural sheetflow from discontinuities in hydrology due to levees, roads, and canals would further exacerbate changes occurring in the vegetative communities in the Greater Everglades. Continuation of altered hydroperiods would have adverse effects on vegetative communities such as degradation due to over drying within northern WCA 3A, WCA 3B, and ENP, and ponding and prolonged high water levels within southern WCA 3A. Sub tidal sea grass beds within Florida Bay would continue to suffer from loss of freshwater flows and high salinities. Some level of improvement to vegetative communities is expected to occur as a result of implementation of projects within the study area with the capability of improving the timing, quantity, and quality of flow to the WCAs, ENP, and Florida Bay (i.e. Broward County Water Preserve Areas Project (USACE 2012c), Biscayne Bay Coastal Wetlands Project (USACE 2012b), C-111 Spreader Canal Western Project (USACE 2011, Everglades Restoration Transition Plan (USACE 2012a), Modified Water Deliveries Project (USACE 2000), Tamiami Trail Modifications: Next Steps Project (DOI 2010)). More natural hydroperiods produced by the implementation of these projects would assist in restoring natural plant communities within the WCAs, ENP, and Florida Bay. Better-timed and greater quantities of water to regions that are now too dry would result in a more natural mosaic of plant communities. Reduction in nutrients would aid in reducing cattail and non-native vegetation that compete with native plants in the system.

C.1.3.2 Fish and Wildlife Resources

The project area supports a variety of fish and wildlife resources. Disruption of the natural hydrology has resulted in aquatic vegetation community changes and a resultant disruption of aquatic productivity and function that has had repercussions through the food chain, including effects on wading birds, larger predatory fishes, reptiles, and mammals. During the period between the present and 2072, a further reduction in habitat function is likely to result in a decrease in the abundance and diversity of fish and wildlife resources.

Desired restoration of historic water fluctuations within Lake Okeechobee would not be accomplished during the period between the present and 2072. Continued artificially high water levels within the lake reduces the availability of bedding habitat for fishes and changes the extent and composition of the emergent and submergent vegetation communities. Lower water levels would provide opportunities for foraging for wading birds and other birds dependent upon aquatic prey species by concentrating prey and exposing additional shallow water habitat.

Altered native habitats dominate the EAA; however remaining wetlands offer some native habitat for fish and wildlife species. Some displacement of wildlife could result from expansion of urban or extractive land cover types within the EAA.

Fish and wildlife resources inhabiting the Northern Estuaries would continue to be impacted by flood control regulatory freshwater releases from Lake Okeechobee. Annual variability in flow would lead to salinity extremes outside the tolerance ranges of many fish and wildlife resources resulting in decreased species diversity. Further declines in estuarine habitat (SAV and oysters) would continue to result in additional declines in the species that utilize these habitats. Seagrass communities within the Northern Estuaries provide critical refugia for juvenile fish. The long term loss of nursery habitat will result in population declines for many species of estuarine and marine fishes and macroinvertebrates, including those whose young of the year use fresher habitats. Waterfowl and wading birds are also expected to decrease by the year 2072 as estuarine habitat quality continues to decline. Some level of improvement is expected to occur as a result of implementation of projects within the study area with the capability of improving the timing, quantity, and quality of freshwater flow to estuarine systems and coastal areas (i.e. C-43 West Basin Storage Reservoir Project (USACE 2010) and Indian River Lagoon South Project (USACE 2004a)).

Throughout the pre-drainage Everglades, the depth, distribution and duration of surface flooding largely determined the distribution, abundance, seasonal movements, and reproductive dynamics of all aquatic and many of the terrestrial animals of the Everglades. Within the Greater Everglades, productivity of native fish species, many important as prey species for wading birds, has been and would continue to be depressed due to water management practices. Nest numbers and success of wading birds have decreased dramatically across south Florida over the past 100 years. Continually decreasing hydroperiods in presently over-drained areas is likely to worsen during the period between the present and 2072. Wading birds will be directly affected by the decreased foraging opportunities provided by shorter and less-frequent hydroperiods. Populations of several terrestrial mammals that are dependent on higher quality habitat or that require large areas of contiguous habitat to survive are also projected to decrease by 2072.

Some level of improvement to fish and wildlife resources is expected to occur as a result of implementation of projects within the study with the capability of improving the timing, quantity, and quality of freshwater flow to the study area (i.e. Broward County Water Preserve Areas Project (USACE 2012c), Biscayne Bay Coastal Wetlands Project (USACE 2012b), C-111 Spreader Canal Western Project (USACE 2011), Everglades Restoration Transition Plan (USACE 2012a), Modified Water Deliveries Project (USACE 2000), Tamiami Trail Modifications: Next Steps Project (DOI 2010)). Water that is retained in the natural system helps maintain proper hydroperiods and stages within the WCAs, ENP, and Florida Bay, thereby increasing usage by fish and wildlife resources.

C.1.3.3 Invasive and Exotic Species

Currently, many non-native invasive species are thriving and negatively affecting the ecology throughout the project area. During the period between present and 2072, it is expected that anthropogenic effects will continue to negatively impact the project area; therefore it is expected new invasions and expansion of current invasive species will continue in the future. Many factors affect future increases and decreases of populations and ranges of invasive species currently present within the project area. Each species has a complex biological heritage which influences its ability to thrive in areas outside of its native range. In addition, there are numerous factors that affect new introductions of invasive species. This constrains the ability to predict new introductions, populations, and ranges of invasive species.

Factors that affect invasive species introductions are presented below. The subtropical climate of south Florida presents a hospitable environment for non-native species from warm parts of the world to establish and become invasive.

Canals within the project area provide deep water refugia for species of tropical fish and serve as pathways for invasive species to travel, spread, and expand into previously uninhabited areas. Drier conditions experienced currently due to compartmentalization and diversion of water will continue due to a lack of restoration projects within this region. The historically wetter areas that are now experiencing drier conditions will continue to shift in vegetation composition. Woody shrubs such as willow and non-native invasive species such as melaleuca will continue to expand in these areas. Continued deliveries of nutrient rich water to the project area will further promote the expansion of cattail.

Environmental manipulation and construction activities, urban development, and agriculture will continue to promote disturbance regimes within south Florida ecosystems that facilitate biological invasions. Disturbance from natural weather events, such as floods, droughts, and hurricanes can provide avenues for invasive species introduction and expansion.

Management of invasive species within the project area is conducted by numerous Federal, state, local, and tribal agencies. However, all control programs within the project area are limited by the level of available funding and staffing. Portions of allocated funding for these programs have been and potentially will be redirected to other programs in the future. While there has been documented success in managing some invasive species (e.g. melaleuca), numerous highly invasive species continue to expand within the study area. Management activities vary in effectiveness which also influences species control and spread within the project area. Management components would be incorporated into CERP projects thereby reducing the presence of some species within those projects. This would also reduce sources for invasions into other areas. Little is known about control and management measures for some species already present, therefore these species will propagate and spread to other areas.

The large aquarium, pet, and ornamental plant industries import new non-native species into Florida on a regular basis. New, imported non-native species introductions will occur through intentional and unintentional releases. On average, 10 new non-native organisms that are capable of establishing, becoming invasive and causing environmental harm are introduced into Florida each year (Cuda 2009). Educational efforts may slightly reduce the number of intentional releases.

The deeper navigation channels and expansion of ports in Florida, such as the Port of Miami and Port Everglades, will provide new trade opportunities for the state. Deeper channels will allow larger container cargo vessels to enter the ports. As a result, it is expected the Port of Miami will double its cargo traffic over the next several years with ships coming from all over the world. Many destructive species have entered the U.S. as stowaways on cargo ships and additional cargo traffic will likely increase this problem.

C.1.3.4 Threatened and Endangered Species

Federally listed threatened and endangered species are either known to exist or potentially exist within the project area. Continued increases in urbanization, water management practices, direct habitat loss, and other land requirements, as well as the degradation of existing habitat function, are likely to result in the continuance of negative population trends of threatened, endangered, and state-listed species of

special concern. Future Federal actions unrelated to the proposed action but located in the study area, will require separate consultations pursuant to Section 7 of the ESA. For further information pertaining to potential impacts to federally listed threatened and endangered species as a result of changes that occur between the present and the future without project condition please see the BA included in **Annex A.**

C.1.3.5 Essential Fish Habitat

Estuarine systems and coastal areas within the project area support fishery resources of recreational and commercial importance. At least 70 percent of Florida's recreationally or commercially sought fishes depend on estuaries for at least part of their life histories. Current disruptions caused by flood control regulatory freshwater releases would continue to cause harm to estuarine systems and coastal areas during the period between the present and 2072. The absence of freshwater flow into estuarine systems and coastal areas would continue to promote conditions that are likely to result in a decrease in the abundance and diversity of species within those habitats. High level freshwater discharges during the wet season would continue to negatively impact species utilizing essential fish habitat. Some level of improvement is expected to occur as a result of implementation of projects within the study area with the capability of improving the timing, quantity, and quality of freshwater flow to estuarine systems and coastal areas (i.e. C-43 West Basin Storage Reservoir Project (USACE 2010), Indian River Lagoon South Project (USACE 2004a), Biscayne Bay Coastal Wetlands Project (USACE 2012b), Broward County WPA Project (USACE 2012c), and C-111 Spreader Canal Western Project (USACE 2011)).

C.1.3.6 Climate

During the period between the present and 2072, south Florida should experience a full multi-decadal cycle of Atlantic hurricane activity. Currently the area is in an active phase of this cycle that started in 1995. This active phase followed a 25-year period of low hurricane activity. This suggests that between the present and year 2072, the area would complete this active phase, pass through another low activity period and begin another active phase. There is now evidence of anthropogenic changes to global climate patterns that will likely have an impact on south Florida in terms of rainfall, evapotranspiration, and temperature (Intergovernmental Panel on Climate change 2007). Climatologists predict air temperatures will increase, with projections of summer temperatures being up to 3°F to 7°F warmer by 2100 (Twilley et.al. 2001, Union of Concerned Scientists 2008). Increases in air temperature, solar radiation, and water vapor deficit due to climate change are expected to increase evapotranspiration. Models used by Calanca et al. (2006) predict a 20 percent increase in evapotranspiration if summer temperatures increase from 4°F to 7°F.

Other sources of climate modeling predict a 1.5°C increase of temperatures in the Everglades and +/- 10% change in precipitation by 2060 (Obeysekera et al. 2011). The temperature change equates to a 7% increase in evapotranspiration. Unless precipitation increases similarly (+7% to +10%), then drought frequency is expected to increase in the Everglades. As a peat soil ecosystem, increasing drought would reduce available water to keep the soils wet, resulting in higher peat oxidation and loss of soil elevations in the freshwater wetlands (FAU 2013). Hydrological modeling indicates that surface water duration may decrease by 10-50% in the Everglades by 2060 (FAU 2013). In parts of northern WCA 3A, peat depths are less than 10 cm above bedrock (Johnson 2012), so loss of peat may produce bedrock protrusions in these areas within this time frame.

Regional surface water storage systems (lakes, rivers, canals, reservoirs, water conservation areas) will most likely experience more rapid water loss when compared to current levels, ultimately impacting availability of water supplies. Increased evapotranspiration may increase water demand for irrigation

and natural wetlands areas. In addition, accelerated evaporation losses from stormwater treatment areas could impact their phosphorus removal performance, increasing the need for supplemental water for these facilities.

The Florida Oceans Council (2009) predicts more frequent intense rainfall events will occur coupled with longer dry periods in between. SFWMD data indicate that there has been an increase in heavy downpours in many parts of the region, while the percentage of the region experiencing moderate to severe drought increased over the past three decades. While periodic heavy downpours may increase overall precipitation totals, much of the water may be runoff that is eventually lost to the Atlantic Ocean and Gulf of Mexico. The environmental impact of changes to floods and droughts depends on the relationship between the climate extremes. If flooding and drought frequency increase together, the Everglades may return to a more natural slough-ridge-island landscape because the floods would redistribute soils and sediments onto ridges and the droughts would allow recruitment of trees on islands. More droughts, without an increase in flooding conditions, pose a threat to the entire South Florida system. They would likely cause large shifts in community structure due to saltwater intrusion into freshwater habitats, drying of inland wetlands, disappearance of ridge and slough microtopography, and an increase in frequency of fires (both terrestrial and wetland). Without the ability to maintain minimum flows and water levels in South Florida, agriculture and public water supply well fields may not be able to function as designed. In addition, well fields may be contaminated by saltwater intrusion and higher salt levels in coastal waters may limit the usefulness of currently installed desalinization plants. More flooding may be good for the Everglades ecosystem because it would stimulate ridge-slough development and restore historic salinity regimes in Biscayne Bay and Florida Bay. However, increasing flooding alone may also create more frequent water level reversals during critical wading bird foraging periods, thus causing further declines in nesting success for wading birds.

Current research indicates overall storm frequency may decrease, while the number of strong hurricanes (due to warmer temperatures) is expected to increase. Tropical storms and hurricanes provide huge amounts of rain for the area. The loss of storm-associated rainfall could have significant implications for the SFWMD regional water supplies. If a decrease in the number of storms does occur, there may be significant changes to the distribution of rainfall, which will affect the water supply and natural ecology of South Florida. Less rainfall may mean the region is under drought conditions more often. If tropical storms and hurricanes become more intense, the potential damage to levees, canals, and other water control structures may also increase – resulting in an increased likelihood of flooding on a local and regional scale. Water supply and water quality may also be adversely affected by this extreme.

Sea level change is one of the more certain consequences of climate change, and because it affects the land/ocean interface, it has the potential for environmental impacts on coastal areas. Various sites along the east coast of Florida indicate that the sea level is rising at a rate above the global average (Maul and Martin 1983). USACE sea level change projections for the period from 2015 to 2065 for Key West, Florida and the broader south Florida area for historic, intermediate and high rates of future sea level rise are +4 inches, +10 inches and +26 inches, respectively http://publications.usace.army.mil/publications/eng-circulars/EC_1165-2-212.pdf. The regional hydrologic models used to simulate with and without project conditions require climatic and tidal data as boundary conditions. Given the uncertainty in future climatic conditions, the historic climate conditions used in the period of record are assumed to represent conditions that are expected to occur in the study area in the future. The model tidal boundary used in the regional hydrologic model was developed using historic tidal data from two primary (Naples and Virginia Key) and five secondary NOAA

stations (Flamingo, Everglades, Palm Beach, Delray Beach, and Hollywood Beach). Simulation model tidal boundary conditions that reflect future sea level change were not available for the range of potential sea level change expected. However, the impact of sea level change on project benefits is assessed for the FWO and with project conditions per USACE guidance EC 1165-2-212. Future rates of sea level change are expected to result in significant impacts on coastal canals and communities, with loss of flood protection and increased saltwater intrusion being the primary effects. Additionally, coastal ecosystems and estuaries are expected to be adversely affected and require additional deliveries of freshwater to maintain desirable salinity patterns and healthy ecosystems. Sea level change is discussed in more detail within **Section C.1.3.10** and **Annex I** .

C.1.3.7 Physical Landscape: Regional Soils and Geology

During the period between the present and 2072, lands within the project area would be disposed and developed consistent with surrounding land use patterns. Within the Greater Everglades, continued loss of organic soils would continue as a result of oxidation. It has been observed throughout the Greater Everglades that peat loss is associated with changes in water deliveries that reduce water depths and hydroperiods. Canal construction and drainage have lead to increased drought intensity and a resultant loss of peat soils. As soil subsides, a minor lowering of topography would be expected. Characteristics of the physical landscape are not expected to change significantly from existing conditions.

C.1.3.8 Hydrology

Hydrologic modeling simulations of the existing condition baseline (ECB) and the CEPP future without project condition (FWO) were developed with the RSM-BN and RSM-GL sub-regional modeling tools, to provide baseline conditions for plan formulation, the assessment of CEPP project benefits (comparisons against FWO), and the assessment of CEPP alternative performance for the level-of-service for flood protection and water supply (comparisons against ECB). The ECB was developed to represent the system-wide infrastructure and operations that were in place at the time CEPP plan formulation was initiated, approximately January 2012. The FWO for CEPP assumes the construction and implementation of currently authorized CERP and non-CERP projects, and other Federal, state or local projects constructed or approved under existing governmental authorities that occur in the CEPP study area; the CEPP FWO therefore included first generation CERP projects already authorized and under construction (Indian River Lagoon South Project, Picayune Strand Restoration Project, Site 1 Impoundment Project), second generation CERP projects authorized by Congress in WRRDA 2014 (Biscayne Bay Coastal Wetlands Project, Broward County Water Preserve Areas Project, Caloosahatchee River (C-43) West Basin Storage Reservoir, C-111 Spreader Canal Western Project), and non-CERP projects currently in progress (SFWMD Restoration Strategies, C&SF C-51 West End Flood Control Project, the C-111 South Dade Project, the Kissimmee River Restoration Project, Modified Water Deliveries, and the DOI Tamiami Trail Modifications Next Steps Project). The CEPP FWO also includes implementation of the Everglades Restoration Transition Strategy (ERTP) WCA 3A Regulation Schedule, which replaced the IOP in October 2012.

Operations protocols for the first and second generation CERP projects were modeled consistent with the draft Project Operating Manuals, as documented in the respective PIRs. The completed Kissimmee River Restoration project included the Headwaters Revitalization Schedule for the Kissimmee Chain of Lakes as defined for the Upper Kissimmee Chain of Lakes Routing (UKISS) modeling conducted by the Kissimmee River project team. The CEPP FWO representation of the C-111 South Dade and Modified Water Deliveries project features do not change operations from the ECB, which includes the L-29 Canal stage constraint at 7.5 feet NGVD, the G-3273 constraint at 6.8 feet NGVD, and the 2011 Interim Operating Criteria for the 8.5 SMA.

The extensive list of first and second generation CERP projects and non-CERP projects that are included in the CEPP FWO will result in hydrologic interactions between the projects. Due to the CERP PIR sequencing and the project-specific assumptions for related projects that were defined in each CERP PIR, the hydrologic interactions observed for the CEPP FWO are likely unique to the CEPP PIR. Based on these considerations, the summary of regional hydrology for the CEPP FWO includes quantitative comparisons with the CEPP ECB based on the RSM-BN and RSM-GL CEPP modeling representations of these baselines.

The portion of the Greater Everglades within the CEPP project area includes WCA 1, WCA 2A, WCA 2B, WCA 3A, WCA 3B, and ENP. This overview of FWO hydrological conditions is intended to provide a general overview of regional hydrological changes compared to the CEPP ECB. For a more detailed assessment, the reader should refer to the complete suite of RSM-GL modeling results. A map depicting the RSM-GL gage locations is provided as **Figure C.1-19**.

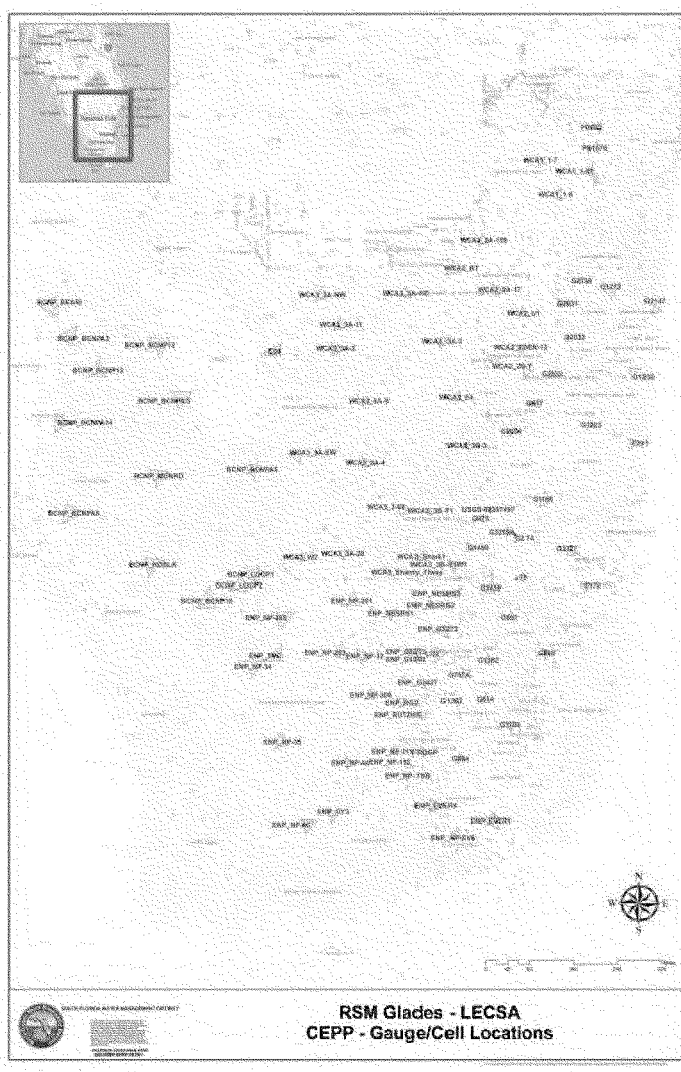


Figure C.1-19. Map of RSM-GL Monitoring Gage Locations

C.1.3.8.1 Lake Okeechobee and the Northern Estuaries

The FWO assumption for the operation of Lake Okeechobee is the Lake Okeechobee Regulation Schedule (LORS) 2008. Compared to the ECB, significant stage reduction of 0.1-0.5 feet for is observed for the upper 75% of the stage duration curve (**Figure C.1-20**), with no modifications to LORS 2008 and assumed implementation of future Kissimmee, C-43, and C-44 restoration projects. The number of days with stages above 16 feet NGVD is reduced from 870 to 696 during the 1965-2005 period of simulation.

For the Caloosahatchee Estuary, compared to the ECB, mean monthly flows above 2800 cfs and 4500 cfs are reduced by 13 and 10 months, respectively (14% and 23% reductions, respectively; **Figure C.1-21**. Mean monthly flows less than 450 cfs are reduced by 89 months (77%) with operation of the C-43 Reservoir (**Figure C.1-22**). For the St. Lucie Estuary, compared to the ECB, mean monthly flows above 2000 cfs and 3000 cfs are reduced by 10 and 12 months, respectively (11% and 28% reductions, respectively; **Figure C.1-23**). Mean monthly flows less than 350 cfs are increased by 3 months (3%) with operation of the C-44 Reservoir (**Figure C.1-24**). Note that the St. Lucie performance measures for the ECB and FWO base conditions were subsequently updated during development of the final array of alternatives, due to an identified error that the performance measure was not accounting for local groundwater flow contributions to the estuary. The correct St. Lucie estuary performance measures are shown in **Figure C.1-23** and **Figure C.1-24**, although these graphics also include display of the subsequent CEPP alternatives.

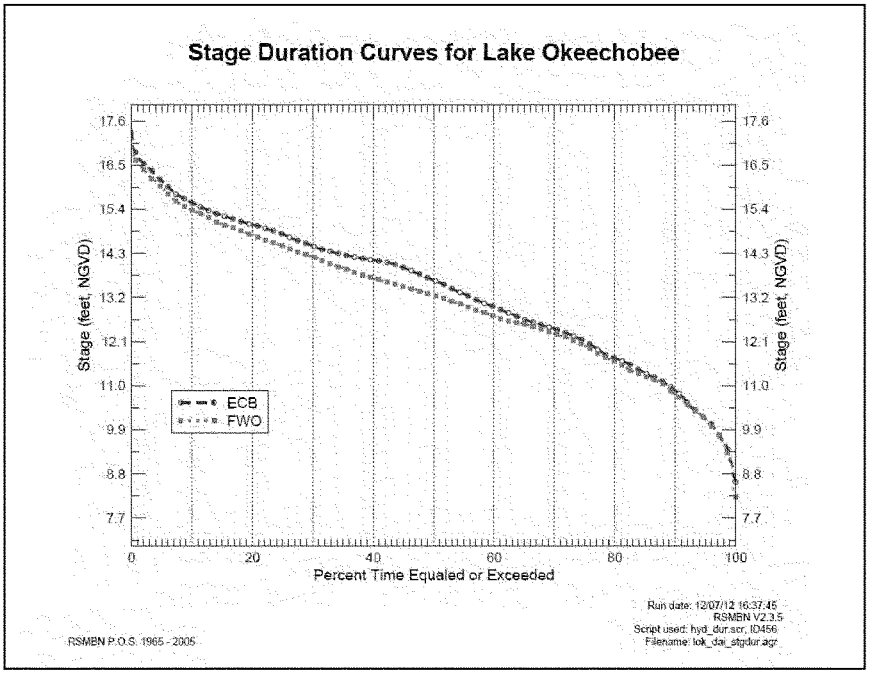


Figure C.1-20. Lake Okeechobee Stage Duration Curve for CEPP Baselines

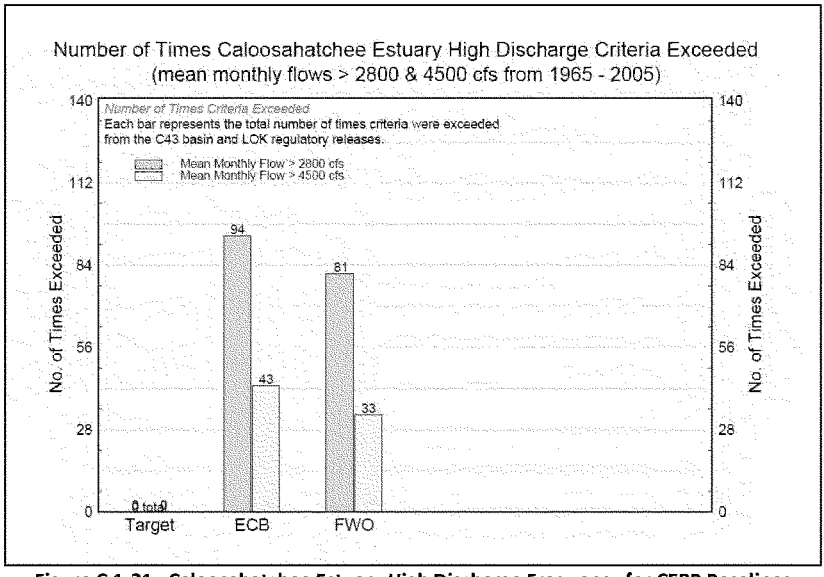


Figure C.1-21. Caloosahatchee Estuary High Discharge Frequency for CEPP Baselines

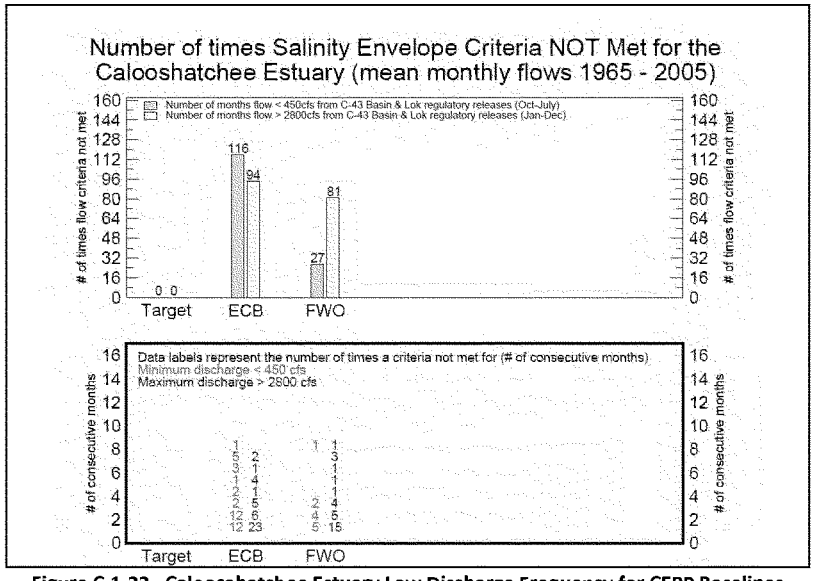


Figure C.1-22. Caloosahatchee Estuary Low Discharge Frequency for CEPP Baselines

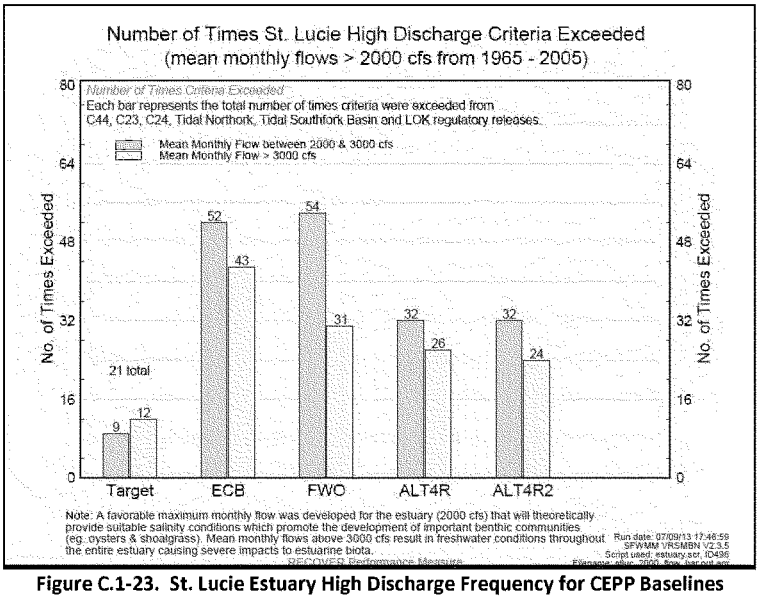


Figure C.1-23. St. Lucie Estuary High Discharge Frequency for CEPP Baselines

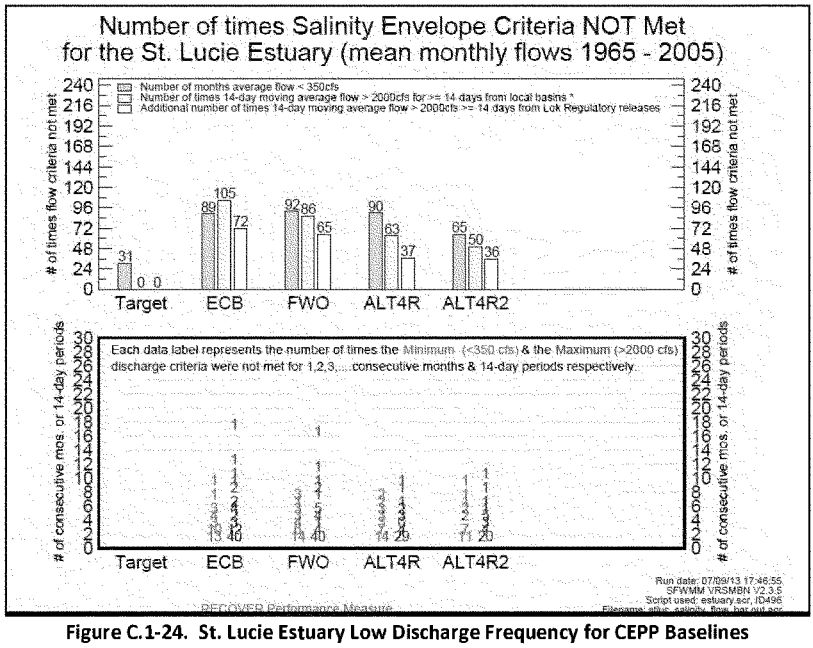


Figure C.1-24. St. Lucie Estuary Low Discharge Frequency for CEPP Baselines

C.1.3.8.2 Everglades Agricultural Area

Minor changes to groundwater levels are expected adjacent to the SFWMD A-1 FEB (15,500 acres), compared to the ECB due to increased seepage from the A-1 FEB. The A-1 FEB design includes perimeter seepage collection canals and associated seepage pumps to limit potential impacts. Detailed CEPP assessments within the EAA are not available because the RSM-BN does not simulate groundwater within the EAA.

C.1.3.8.3 Water Conservation Area 1

Compared to the ECB, no significant changes to WCA 1 stages are indicated. Average annual regulatory releases from WCA 1 to WCA 2A via the S10 structures are moderately reduced from 282,000 acre-feet (282 kAF) to 268 kAF.

C.1.3.8.4 Water Conservation Area 2A and 2B

Compared to the ECB, stages within WCA 2A are generally increased by 0.1-0.2 feet under all hydrologic conditions (**Figure C.1-25**). Average annual inflows from STA 2 (including Compartment B) to WCA-2A are increased from 230 kAF to 381 kAF (a 66% increase) following assumed implementation of the SFWMD Restoration Strategies Project, including the A-1 FEB. The S-7 pump station also contributes inflows to WCA 2A; S-7 inflows are increased from 25 kAF in the ECB to 77 kAF in the FWO. Average annual regulatory releases from WCA-2A to WCA 3A via the S11s are increased from 382 kAF to 460 kAF. Compared to the ECB, stages within WCA 2B are significantly increased by 0.25-0.50 feet under nearly all hydrologic conditions, excluding extreme wet conditions (**Figure C.1-26**). Changes within WCA 2B are directly related to the increased stages within WCA 2A and increased inflows from S-144, S-145, S-146, and seepage.

C.1.3.8.5 L-28 Triangle

Stages within the L-28 Triangle do not change significantly between the CEPP ECB and the FWO.

C.1.3.8.6 Big Cypress National Preserve

Stages within the BCNP, west of WCA 3A, do not change significantly between the CEPP ECB and the FWO.

C.1.3.8.7 Water Conservation Area 3A and 3B

The CEPP FWO includes the combined effects from implementation of the SFWMD A-1 FEB, the ERTP WCA 3A Regulation Schedule (the CEPP ECB assumed the IOP WCA 3A Regulation Schedule), and the CERP Broward WPA Project, in addition to downstream affects associated with the stage reductions in Lake Okeechobee and reduced regulatory discharges south. Compared to the ECB, average annual combined structural inflows to WCA 3A from STA 3/4, STA 5/STA 6 (including Compartment C), and WCA 2A are reduced from 1,073 kAF to 1,028 kAF (a 4% reduction) following assumed implementation of the SFWMD A-1 FEB. Average annual combined structural outflows from WCA 3A through the S-151 (to WCA-3B), S-333 (to ENP NESRS), the S-12 structures (to ENP WSS), and the S343/S344 culverts are also slightly reduced from 1,205 kAF to 1,190 kAF, consistent with the reduced inflows to WCA 3A.

Since WCA 3A covers approximately 752 square miles, hydrologic differences between the CEPP ECB and FWO are characterized at representative gages throughout WCA 3A. Within northwest WCA 3A, no significant differences are observed compared to the ECB, although stages are slightly increased during the wettest 20% of conditions (**Figure C.1-27**). By comparison, stages within northeast WCA 3A are generally decreased by 0.1-0.2 feet, with no significant change during extreme wet or extreme dry conditions (**Figure C.1-28**). Within east-central WCA 3A (3A-3), stages are generally decreased by 0.1-0.2

feet, with no significant change during extreme wet or extreme dry conditions (**Figure C.1-29**. Proceeding south within central WCA 3A (3A-4), stages are similarly generally decreased by 0.1-0.2 feet, with no significant change during extreme wet or extreme dry conditions (**Figure C.1-30**). Southern WCA 3A (3A-28) stages are generally more notably decreased by 0.2-0.3 feet, also with no significant change during extreme wet or extreme dry conditions (**Figure C.1-31**).

Stages in WCA 3B (Site 71) are generally decreased by 0.1-0.2 feet during normal to dry conditions (**Figure C.1-32**), due to the reduced structure inflows from S-151 and reduced seepage inflows resultant from the slight reduction in WCA 3A stages.

C.1.3.8.8 Northeast Shark River Slough

The normal operational target flow distribution is 55 percent through the S-333 into NESRS and 45 percent through the S-12 structures into ENP west of the L-67 Extension, although the ERTP additionally includes provisions for dry season conditions or unseasonably dry conditions when ENP recommends that the percent distribution is not limited to 55 percent to NESRS.

Compared to the ECB, stages within NESRS (NESRS-2) are slightly reduced during normal to dry conditions (**Figure C.1-33**). Similar trends are also observed further south at the NESRS-1 monitoring gage. This stage reduction within NESRS is comparable to upstream water level trends observed within WCA-3A. Inclusion of ERTP operations, in isolation, within the CEPP FWO would be expected to slightly increase WCA 3A Rainfall Plan deliveries to NESRS during dry conditions, and the FWO modeling does indicate a moderate increase in S-333 average annual discharges from 130 kAF to 137 kAF (a 5% increase). The potential increased hydrologic connectivity between WCA-3B and NESRS with the FWO-assumed completed 1-mile eastern MWD Tamiami Trail bridge and the 2.6-mile western DOI Tamiami Trail Next Steps bridge (both bridges and the associated Tamiami Trail roadway raising are included in the FWO and are not included in the ECB) is not realized in the CEPP FWO because the L-29 Canal maximum operational limit (7.5 feet NGVD) and the G-3273 stage constraint (6.8 feet NGVD) remain unchanged from the CEPP ECB, in the absence of an assumed future operational plan that integrates these features. Additional detail can be found in the ERTP EIS (USACE 2012a).

C.1.3.8.9 Western Shark River Slough

Western SRS, located to the west of L-67 Extension Levee and bounded on the north by Tamiami Trail, is primarily influenced by rainfall and water management operations at the S-12 structures (A, B, C and D). Under ERTP, the utilization of the S-12 structures and the seasonal sequential closure periods beginning from the west at S-12A (November 1 – July 14) and S-12B (January 1 – July 14), respectively, is meant to move water from WCA 3A into SRS while providing conditions for Cape Sable seaside sparrow Subpopulation-A (CSSS-A) nesting and breeding. Compared to IOP 2006, the operational plan included in the CEPP ECB, ERTP removed the seasonal closure for S-12C (February 1- July 15). Although not required in water management operations, there is a rule-of-thumb that is often utilized (although not a constraint under ERTP) that includes delivering the Rainfall Plan S-12 structure target flows from east to west with 40 percent, 30 percent, 20 percent, and 10 percent being discharged at S-12D, S-12C, S-12B, and S-12A, respectively. Releases from WCA-3A are part of a regulation schedule for WCA 3A and are typically dependent on a Rainfall Based Management Plan (USACE 2006a). This Rainfall Based Management Plan consists of a rainfall-based delivery formula that specifies the amount of water to be delivered to ENP in weekly volumes through the S-333 and S-12 structures. Under ERTP, the normal operational target flow distribution is 55 percent through S-333 into NESRS and 45 percent through the S-12 structures into ENP west of the L-67 Extension, although the ERTP additionally includes provisions

for dry season conditions or unseasonably dry conditions when ENP recommends that the percent distribution is not limited to 55 percent to NESRS.

Compared to the ECB, stages within northwest ENP (NP-201) are generally increased by 0.1-0.2 feet during normal to dry conditions (**Figure C.1-34**) due to the increased utilization of S-12C with ERTP. NP-201 stage responses are highly correlated to the increased utilization of S-12C associated with the ERTP operations. Stages further south within Central Shark River Slough (P-33) demonstrate no significant change between the ECB and FWO (**Figure C.1-35**). Compared to the ECB, no significant stage differences are noted at NP-205, aside from a slight reduction in stage during wet to normal (not extreme) hydrologic conditions.

C.1.3.8.10 Taylor Slough

Under the ECB, which includes IOP 2006 operations for the SDCS, specified C-111 basin canal water levels/ranges and S-332D pump station operations resulted in Taylor Slough being provided water from C-111 mainly during the wet season. During the dry season, under IOP 2006, water deliveries to Taylor Slough were limited to provide conditions conducive to CSSS nesting (325 cfs from December 1 – January 31; 165 cfs from February 1 – July 15). ERTP operations, as part of the CEPP FWO, slightly modify the S-332D operations by increasing the CSSS operational constraint up to 250 cfs during the period from February 1 – July 14.

Compared to the ECB, ENP stages along Taylor Slough (NP-TSB) are generally increased by 0.1-0.3 feet during nearly all hydrologic conditions (**Figure C.1-36**). Increased stages for Taylor Slough are resultant from the combined hydrologic effects of the ERTP S-332D operations, the CERP C-111 Spreader Canal Western Project, and the non-CERP C-111 South Dade L-31W Canal plug constructions, as assumed completed for the FWO condition.

C.1.3.8.11 Lower East Coast Area

The LEC area is located to the east of the L-31N, L-31W, and C-111 canals. Under IOP 2006 and ERTP, specified canal water levels/ranges are meant to provide flood protection, water supply, and prevention of saltwater intrusion for the LEC. The ERTP operations for the SDCS are unchanged from the IOP operations for the SDCS, resulting in no changes to the operational protocols between the CEPP ECB and FWO.

Observed stage changes within the LEC are separately discussed with the FWO summary of flood control and water supply performance.

C.1.3.8.12 8.5 Square Mile Area

Stages within the 8.5 SMA, located along the eastern boundary of ENP, do not change significantly between the CEPP ECB and the FWO as ERTP did not change the operations of the 8.5 SMA S-357 pump station or the adjacent SDCS structure operations. The 8.5 SMA project components and operations are unchanged between the ECB and FWO modeling assumptions.

C.1.3.8.13 Biscayne Bay

No significant changes to combined total surface water canal discharges to central and southern Biscayne Bay (S-336, S-338, S-194, S-196, and S-197) or regional groundwater stages are observed between the CEPP ECB and FWO. Average annual surface water canal discharges to northern Biscayne Bay (S-29, S-28, S-27), which are affected by the assumed operations of the CERP BCWPA project, are increased by 66 kAF in the FWO, compared to the ECB.

C.1.3.8.14 Florida Bay

Average annual surface water transect flows from southeastern ENP towards Florida Bay are unchanged for Craighead Basin (RSM-GL Transect 23-A), increased by 8 kAF (12%) from Taylor Slough (Transect 23-B), and decreased by 22 kAF (13%) for the Eastern Panhandle of ENP (Transect 23-C), resulting in a net decrease of approximately 14 kAF for the FWO, compared to the ECB. Changes in surface water transect flows towards eastern Florida Bay are resultant from the combined hydrologic effects of the ERTP S-332D operations, the CERP C-111 Spreader Canal Western Project, and the non-CERP C-111 South Dade L-31W Canal plug constructions, as assumed completed for the FWO condition. The salinity effects within Florida Bay from this overall reduction and changed spatial distribution of flows were not specifically evaluated by the CEPP ecological sub-team (with additional RECOVER support), but limited additional information for the FWO changes compared to the ECB are also shown in **Appendix G (Benefit Model)**.

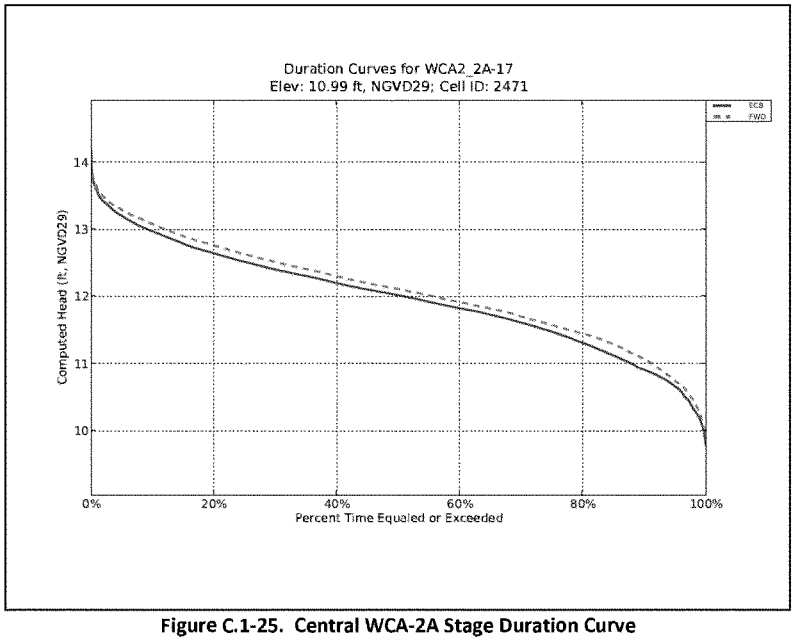


Figure C.1-25. Central WCA-2A Stage Duration Curve

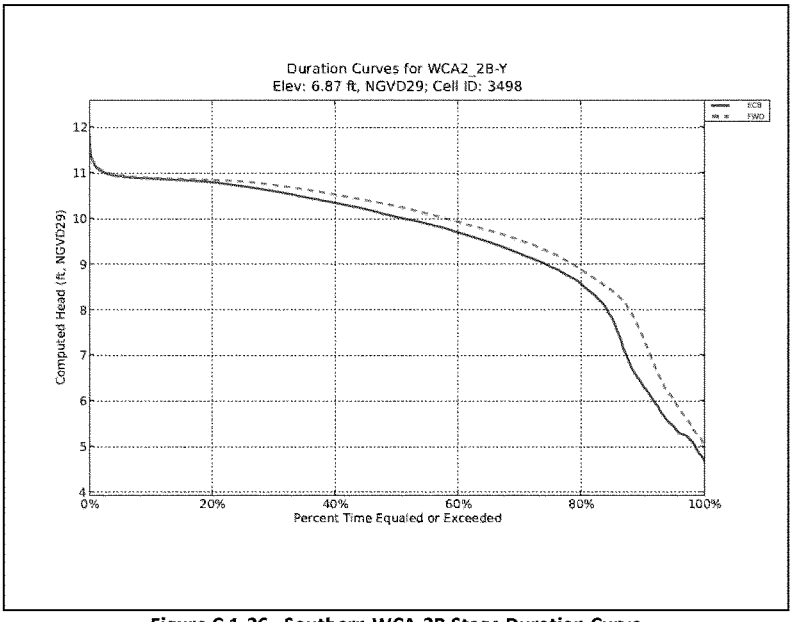


Figure C.1-26. Southern WCA-2B Stage Duration Curve

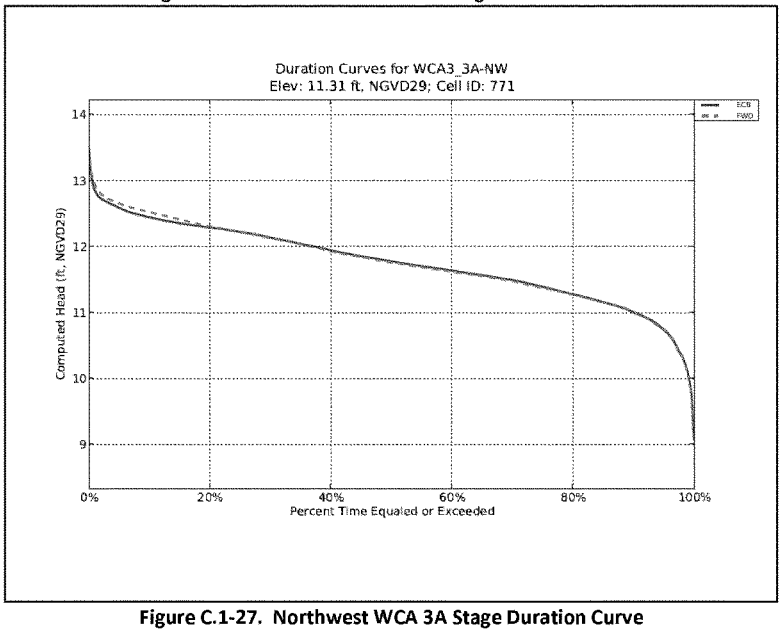


Figure C.1-27. Northwest WCA 3A Stage Duration Curve

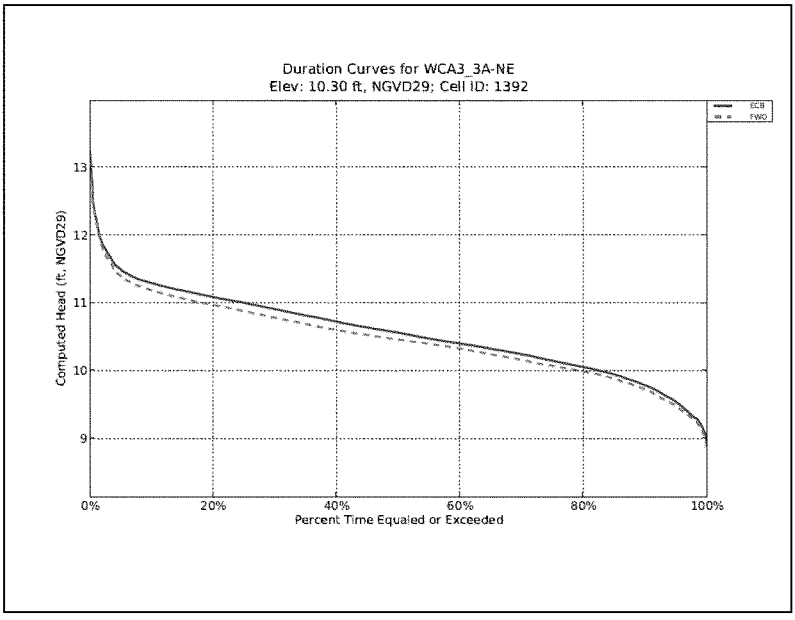


Figure C.1-28. Northeast WCA 3A Stage Duration Curve

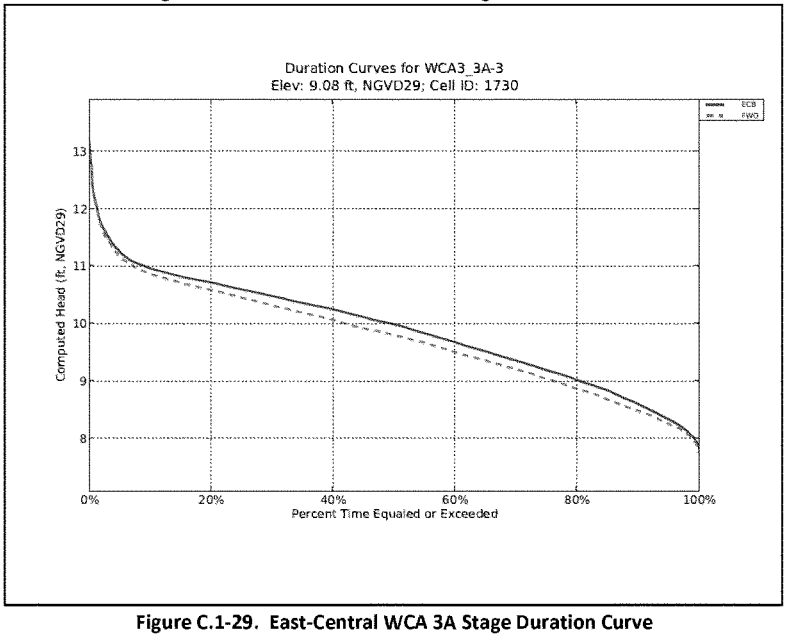


Figure C.1-29. East-Central WCA 3A Stage Duration Curve

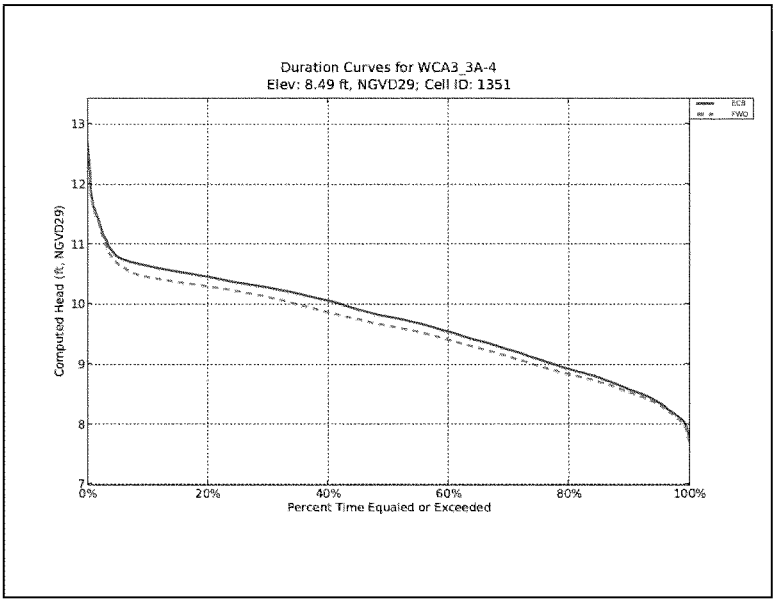


Figure C.1-30. Central WCA 3A Stage Duration Curve

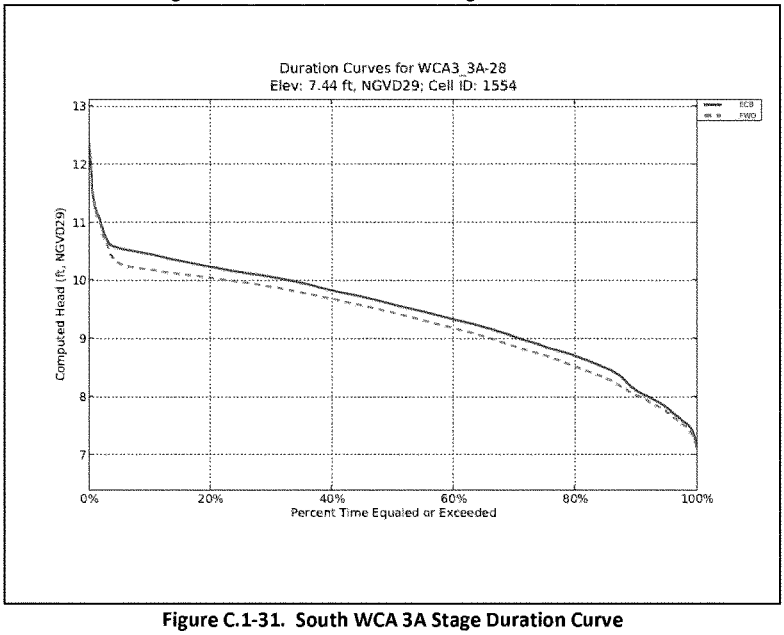


Figure C.1-31. South WCA 3A Stage Duration Curve

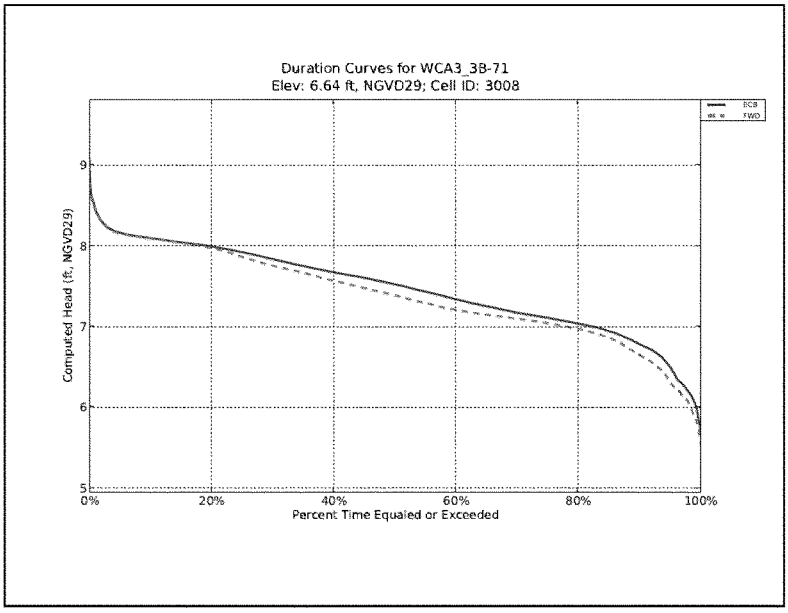


Figure C.1-32. Central WCA-3B Stage Duration Curve

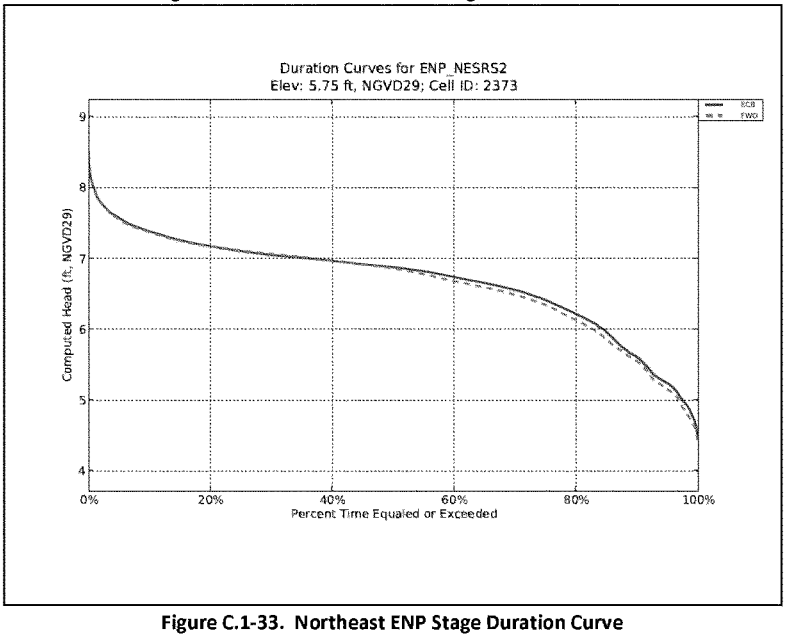


Figure C.1-33. Northeast ENP Stage Duration Curve

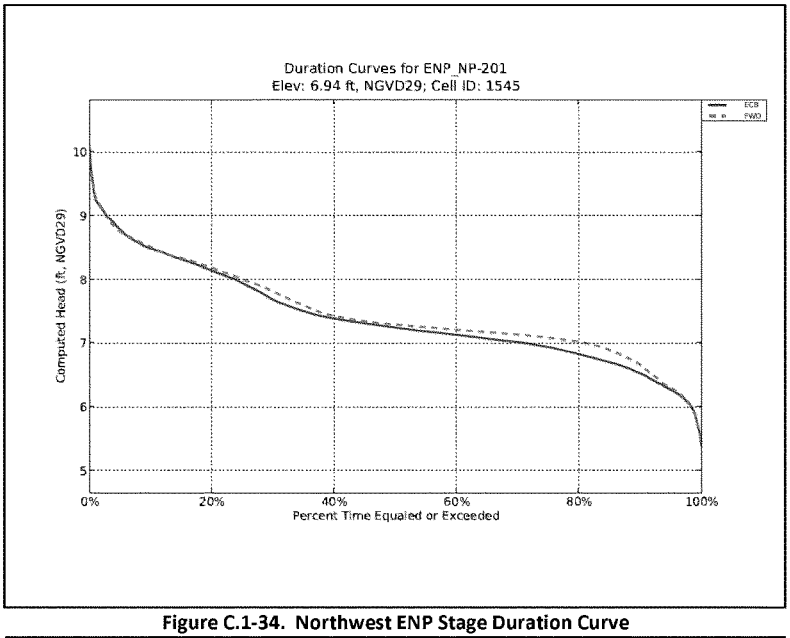


Figure C.1-34. Northwest ENP Stage Duration Curve

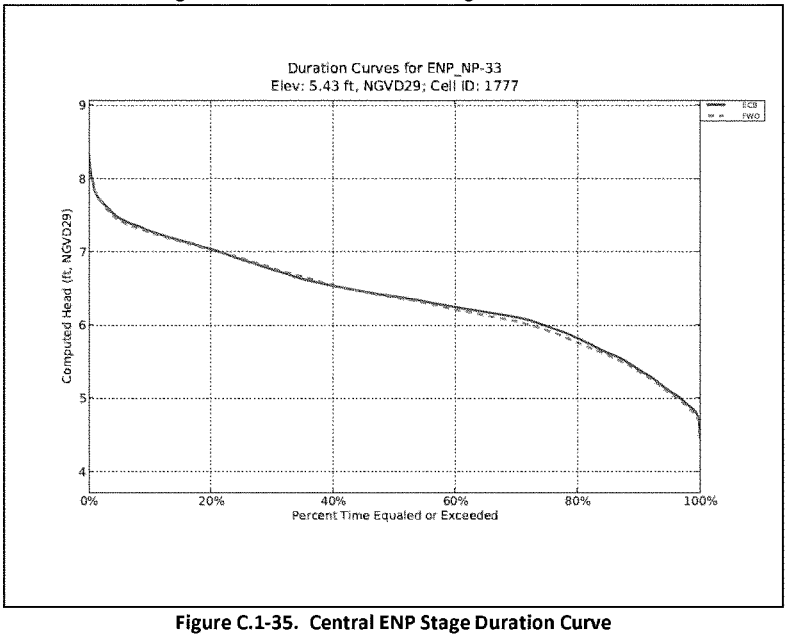


Figure C.1-35. Central ENP Stage Duration Curve

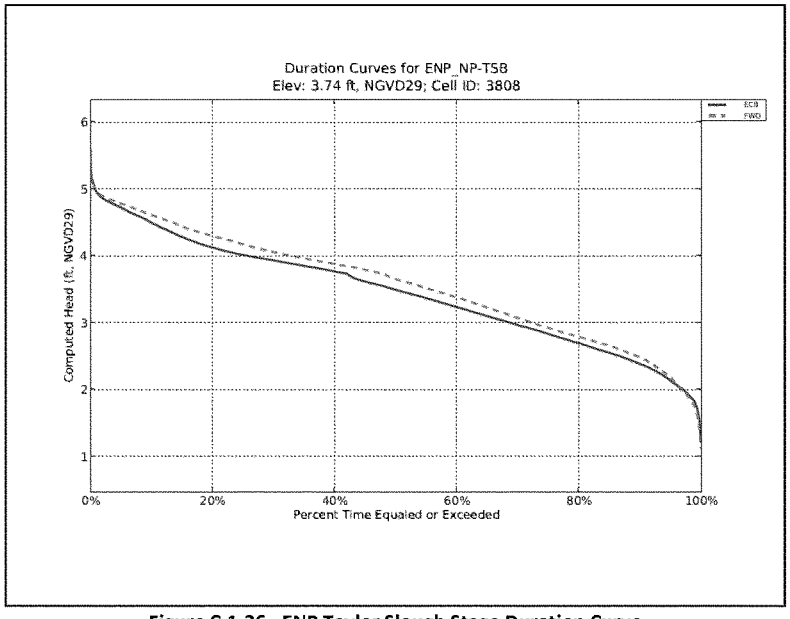


Figure C.1-36. ENP Taylor Slough Stage Duration Curve

C.1.3.9 Regional Water Management (Operations)

The FWO for CEPP assumes the construction and implementation of currently authorized CERP and non-CERP projects, and other Federal, state, or local projects constructed or approved under existing governmental authorities that occur in the CEPP study area; the CEPP FWO therefore included first generation CERP projects already authorized and under construction (Indian River Lagoon-South Project, Picayune Strand Restoration Project, Site 1 Impoundment Project), second generation CERP projects authorized by Congress in WRRDA 2014 (Biscayne Bay Coastal Wetlands Project, Broward County Water Preserve Areas Project, Caloosahatchee River (C-43) West Basin Storage Reservoir, C-111 Spreader Canal Western Project), and non-CERP projects currently in progress (SFWMD Restoration Strategies, C&SF C-51 West End Flood Control Project, the C-111 South Dade Project, the Kissimmee River Restoration Project, Modified Water Deliveries, and the DOI Tamiami Trail Modification Next Steps Project).

For CEPP modeling of the FWO with the RSM-BN and RSM-GL models, operations protocols for the first and second generation CERP projects were modeled consistent with the draft Project Operating Manuals, as documented in the respective PIRs. The completed Kissimmee River Restoration project included the Headwaters Revitalization Schedule for the Kissimmee Chain of Lakes as defined for the UKISS modeling conducted by the Kissimmee River project team. The CEPP FWO representation of the C-111 South Dade and Modified Water Deliveries project features do not change operations from the ECB, which includes the L-29 Canal stage constraint at 7.5 feet NGVD, the G-3273 constraint at 6.8 feet NGVD, and the 2011 Interim Operating Criteria for the 8.5 SMA. Therefore, effects are as described in **Section C.1.1.9**.

C.1.3.9.1 Lake Okeechobee

The FWO assumption for the operation of Lake Okeechobee is the LORS 2008. The CEPP team recognizes that when it was approved, LORS 2008 was identified as an interim schedule and that a subsequent schedule would be considered after the modifications to Herbert Hoover Dike (HHD) were completed. Until a new operating schedule is developed under a different, future study, LORS 2008 is the best estimate for operations.

The CEPP FWO modeling assumed operation of Lake Okeechobee as specified in the November 2007 LORS Final EIS (ROD approved in April 2008), with the other specified adjacent FWO projects (Kissimmee River Restoration, Caloosahatchee River (C-43) West Basin Storage Reservoir, Indian River Lagoon-South Project) in place and operational; Lake Okeechobee FWO operations were not further optimized during CEPP to consider utilization of additional operational flexibility, including potential higher lake stages. Therefore, effects are as described in **Section C.1.1.9.1**.

C.1.3.9.2 Greater Everglades

The CEPP FWO assumes implementation of the SFWMD Restoration Strategies, including construction of the A-1 FEB impoundment and 6,500 acres of additional STA treatment wetlands, within the EAA to achieve compliance with the 2012 FDEP Consent Order for water quality inflows to the EPA. The September 2012 Consent Order issued to the SFWMD by the FDEP is the result of extensive negotiations between the state and Federal parties. The Central Flow-way components of the SFWMD Restoration Strategies are included in the CEPP FWO modeling.

No modifications to the WCA 1 or WCA 2 Regulation Schedules are included in the CEPP FWO, and operations of these WCAs are consistent with the ECB. Effects would be as described in **Section C.1.1.9.2** with respect to WCA 1 and 2.

In addition to the CERP and non-CERP projects previously specified, the CEPP FWO includes implementation of the ERTP operational plan for WCA 3A, ENP, and the SDCS, which has replaced the IOP. The ERTP superseded the IOP in October 2012 and is intended to be a transitional temporary plan to be used until completion of the final Operational Plan that was to be developed as part of the MWD project. Under the ERTP, WCA 3A is regulated according to a seasonally varying 8.75 to 10.50 feet NGVD regulation schedule and a slightly modified Rainfall Plan, as per the ERTP (December 2011 ERTP Final EIS; refer to **Figure C.1-37**). The most notable changes with the WCA 3A Interim Regulation Schedule under ERTP, compared to that under IOP, are the following changes (refer to the ERTP Final EIS for additional details): the top of the WCA 3A Interim Regulation Schedule (Zone A) was lowered seasonally by between 0.25-0.50 feet; the IOP Regulation Schedule transition zones (Zones B and C) were eliminated; the bottom zones (Zone D and Zone E1) were extended; the S-12C seasonal closure under IOP (February 1 through July 14) was removed; and ERTP operations will utilize the FWS Multi-species Transition Strategy (MSTS) and Periodic Scientists Calls (PSC) to provide input to assist the USACE with operational decision-making. Under the ERTP, consistent with IOP, the WCA 3A Interim Regulation Schedule utilizes a 3-gauge average elevation of Sites 63, 64, and 65 in the management of WCA 3A water levels (also known as 3A-3, 3A-4 and 3A-28, respectively). Consistent with the IOP, the goal of the rainfall and regulatory components is to split the flows between the S-12 structures and S-333, with 45 percent of the total flow from WCA 3A passing through the S-12 structures to Western SRS and the remaining 55 percent to discharge through S-333 to NESRS, establishing the target flows for both the S-12 structures and S-333. However, the ERTP additionally includes provisions for dry season conditions or unseasonably dry conditions when ENP recommends that the percent distribution is not limited to 55 percent to NESRS.

Water deliveries to eastern ENP remain controlled by the stage in L-29 Canal in the CEPP FWO assumptions. Consistent with the ECB, the water management operating criteria for the L-29 borrow canal between S-333 and S-334 is meant to limit the L-29 borrow canal stage to no more than 7.5 feet NGVD in response to existing roadway sub-base concerns identified by the Florida Department of Transportation (FDOT). Although the CEPP FWO assumes completion of the MWD Tamiami Trail Modifications project, the final Operational Plan for MWD has not been developed. Therefore, for planning purposes the CEPP FWO includes ERTP as the operational plan. Also unchanged from the ECB operations for ENP, when the G-3273 water level within NESRS reaches 6.8 feet, NGVD under FWO operations, S-333 discharges to NESRS will be discontinued until G-3273 falls below 6.8 feet, NGVD.

There are three distinct modes of water management operations for ERTP, which are consistent with the previous IOP: Column 1, Column 2, and water supply. Water management operating criteria within Column 1 occurs when WCA 3A discharges can be achieved by discharges from the S-12 structures, S-333, S-151, S-343A, S-343B, and/or S-344. Water management operating criteria within Column 2 occurs when WCA 3A discharges are made via S-333 to the L-29 Canal and L-31N Canal, the ENP SDCS; Column 2 generally requires the use of pump stations S-331, S-332B, S-332C, and S-332D. Column 2 is used to offset or mitigate for adverse effects on WCA 3A related to closure periods at water management structures to protect CSSS-A. Column 2 generally occurs when any S-12 structure is closed in order to protect the Cape Sable seaside sparrow (CSSS) (January 1 through July 14, under ERTP), although Column 1 may continue until the capacity of the S-12 structures that remain open is insufficient to handle the discharge from WCA-3A. If necessary, Column 2 may continue past re-opening of the S-12 structures (July 15) to mitigate for adverse effects on WCA 3A resulting from the ERTP closures of S-12A, S-12B, S-343A, S-343B, and S-344. All other specified operations in the CEPP FWO for WCA 3A, WCA 3B, and ENP are unchanged from the ECB. Additional detail is included in the December 2011 ERTP Final EIS and is incorporated by reference in this document.

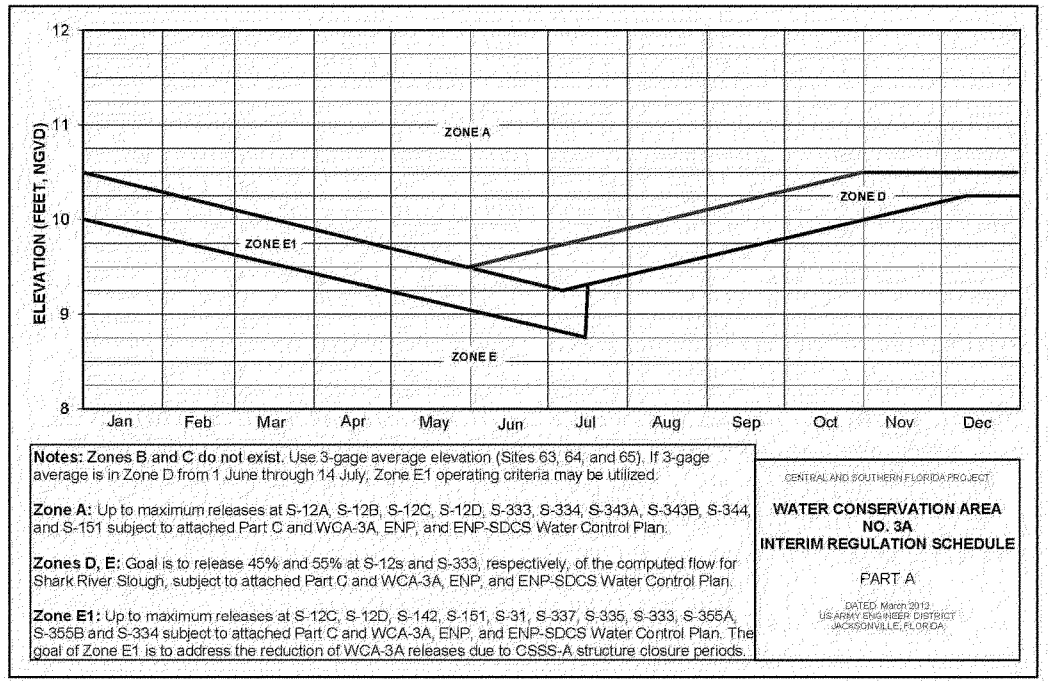


Figure C.1-37. ERTP Water Conservation Area 3A Interim Regulation Schedule Part A

C.1.3.10 Flood Control

The negative effects associated with flooding are expected to increase during the period between the present and the year2072. As agricultural and urban development continues, the volume, duration, and frequency of floodwaters may increase, and the actual levels of service for flood control may decline in some areas. If sea level change continues as predicted, it is foreseeable that the Biscayne aquifer is likely to experience greater intrusion of saltwater possible rendering some of the current water supply well fields unusable due to contamination. Higher groundwater stages in the project area would reduce the ability of water managers to store rainfall runoff wither within wetlands or the surficial aquifer, resulting in increased intensity of stormwater discharges through the primary canals. Reduced water storage reduces the capacity of the flood control system to accommodate runoff and would likely lead to increased frequency of flooding events. Sea level change may also impact flood control effectiveness as rising tail water conditions at the coastal canal structures reduce the effective maximum discharge rates. As additional information becomes available, these structures may be modified or replaced with pumps to ensure continued effective flood control. This may also require the implementation of forward pumping to maintain the existing level of flood protection in the future. An analysis of sea level change on the recommended plan is discussed in **Section 6** and **Annex I**. Sea level change is not included in the FWO modeling for CEPP.

Future non-CERP projects, implemented through the USACE and/or the SFWMD may potentially alter the levels of service for flood control within the CEPP project area, including but not limited to: potential Lake Okeechobee Regulation Schedule changes, SFWMD Restoration Strategies, C&SF C-51 West End Flood Control Project, the C-111 South Dade Project, the Kissimmee River Restoration Project, Modified Water Deliveries, and other potential future C&SF operational plan studies. Potential flood control affects, including improved or reduced levels of service, would be thoroughly assessed through the public NEPA process. To the extent that these projects have been identified and defined, these non-CERP projects have been included in the CEPP FWO modeling assumptions; potential future operational plans for Lake Okeechobee, implementation of the Modified Water Deliveries and C-111 South Dade projects, and other potential future C&SF operational plan studies are therefore not able to be included in the CEPP FWO modeling.

The Water Resources Development Act of 2000 (section 601 of WRDA 2000) approved the CERP Plan contained in the "Final Integrated Feasibility Report and Programmatic Environmental Impact Statement" dated April 1, 1999. As stated in section 601(h) of WRDA 2000, "the overarching objective of the Plan is the restoration, preservation, and protection of the south Florida ecosystem while providing for other water-related needs of the region, including flood protection and water supply." Section 601 of WRDA 2000 required the Secretary of the Army, with the concurrence of the Secretary of the Interior and the Governor of Florida, and after notice and opportunity for public comment, to promulgate Programmatic Regulations to ensure that the goals and purposes of the Plan are achieved and to establish the processes necessary for implementing the Plan. The final Programmatic Regulations became effective on December 12, 2003 as Title 33, Part 385 of the Code of Federal Regulations (CFR).

Identifying if an elimination or transfer of existing legal sources of water will occur as a result of implementation of CERP and whether levels of service for flood protection will be reduced by implementation of CERP is required by section 601(h)(5) of WRDA 2000. The WRDA 2000 Savings Clause requires that "Implementation of the Plan shall not reduce levels of service for flood protection that are: (i) in existence on the date of enactment of this Act (December 11, 2000); and (ii) in accordance with applicable law." Consistent with the Savings Clause requirements, each CERP project included in the CEPP FWO (Indian River Lagoon-South Project, Picayune Strand Restoration Project, Site 1

Impoundment Project, Biscayne Bay Coastal Wetlands Project, Broward County Water Preserve Areas Project, Caloosahatchee River (C-43) West Basin Storage Reservoir, C-111 Spreader Canal Western Project) must independently demonstrate in the respective PIRs that implementation of these CERP projects would not adversely impact the levels of service for flood protection. Operations protocols for the first and second generation CERP projects were modeled in the CEPP FWO consistent with the draft Project Operating Manuals, as documented in the respective PIRs.

Compared to the CEPP ECB, the CEPP FWO modeling indicated no change to flood control stages within the wettest 10% of hydrologic conditions for LECSA 1 (Palm Beach) and LECSA 2 (Broward); no change to flood control stages within the wettest 10% of hydrologic conditions along the L-30 Canal in LECSA 3 (Miami); and a slight increase to flood control stages within the wettest 10% of hydrologic conditions along the L-31N Canal in LECSA 3.

C.1.3.11 Water Supply

Future non-CERP projects within the CEPP project area, implemented through the USACE and/or the SFWMD may potentially partially or entirely eliminate water supply sources or transfer water supply to new sources. Currently identified future non-CERP projects including, but are not limited to: potential Lake Okeechobee Regulation Schedule changes, the C-111 South Dade Project, the Kissimmee River Restoration Project, Modified Water Deliveries, and other potential future C&SF operational plan studies. Potential water supply affects, including improved or reduced levels of service, would be thoroughly assessed through the public NEPA process. To the extent that these projects have been identified and defined, these non-CERP projects have been included in the CEPP FWO modeling assumptions; potential future operational plans for Lake Okeechobee, implementation of the Modified Water Deliveries and C-111 South Dade projects, and other potential future C&SF operational plan studies have not been presently defined and were therefore not included in the CEPP FWO modeling.

Identifying if an elimination or transfer of existing legal sources of water will occur as a result of implementation of CERP and whether levels of service for flood protection will be reduced by implementation of CERP is required by section 601(h)(5) of WRDA 2000. The WRDA 2000 Savings Clause requires that "Until a new source of water supply of comparable quantity and quality as that available on the date of enactment of this Act is available to replace the water to be lost as a result of implementation of the Plan, the Secretary and the non-Federal sponsor shall not eliminate or transfer existing legal sources of water, including those for: (i) an agricultural or urban water supply; (ii) allocation or entitlement to the Seminole Tribe of Florida under section 7 of the Seminole Indian Land Claims Settlement Act of 1987; (iii) the Miccosukee Tribe of Indians of Florida;(iv) water supply for Everglades National Park; or (v) water supply for fish and wildlife." Consistent with the Savings Clause requirements, each CERP project included in the CEPP FWO (Indian River Lagoon-South Project, Picayune Strand Restoration Project, Site 1 Impoundment Project, Biscayne Bay Coastal Wetlands Project, Broward County Water Preserve Areas Project, Caloosahatchee River (C-43) West Basin Storage Reservoir, C-111 Spreader Canal Western Project) must independently demonstrate in the respective PIRs that implementation of these CERP projects would not adversely impact the existing legal sources for water supply. Operations protocols for the first and second generation CERP projects were modeled in the CEPP FWO consistent with the draft Project Operating Manuals, as documented in the respective PIRs.

C.1.3.11.1 Lake Okeechobee

In the Lake Okeechobee Service Area, which includes the EAA, the volume of available fresh water is limited. Specifically, the Lake Okeechobee is a limited source due to implementation of the 2008 LORS,

and concerns regarding the lake's MFL criteria. As a result of the impacts to water supply, the SFWMD enacted rules to limit future additional withdrawals from Lake Okeechobee in order to prevent further degradation of the level of certainty for existing legal users.

Despite limitations on future demand (no water supply demand increases are included in the FWO modeling), compared to the ECB, the frequency of water restrictions within the Lower East Coast Service Areas is projected to slightly increase for the CEPP FWO due to Lake Okeechobee falling below the Water Shortage Trigger line as defined by LOWSM: 3 additional years with 3 or more months with restrictions for LECSA 1; 1 additional years with 3 or more months with restrictions for LECSA 2; and 3 additional years with 3 or more months with restrictions for LECSA 3. When HHD remediation of Reaches 1, 2, and 3 and replacement/removal of culverts are complete and the HHD DSAC Level 1 rating is lowered, it may be possible to allow higher maximum lake stages and increased frequency and duration of high lake stages, but this assumption was not included in the CEPP modeling (2008 LORS is assumed for the CEPP FWO, without use of additional operational flexibility). In addition, completion of the Kissimmee River Restoration Project and implementation of a new operating schedule is expected in the FWO. As a result inflows to the Lake would have a different seasonal pattern and magnitude, though the new operating schedule is not known nor included in the FWO analysis.

The CERP C-43 and C-44 reservoirs are assumed to be constructed and operational in the FWO condition, but these projects would not be expected to affect Lake Okeechobee stages. C-43 reservoir captures Lake Okeechobee regulatory releases and the C-44 reservoir captures local basin stormwater runoff. Likewise, implementation of the SFWMD Restoration Strategies' water quality treatment projects in the FWO condition are not expected to affect Lake Okeechobee stages or its ability to supply supplemental irrigation. Most of the land being converted for water quality projects has not been used for agricultural production for a number of years. In addition, the SFWMD Restoration Strategies' projects have been designed to capture existing run-off from the EAA and only the historical limit of up to 60,000 acre feet of water from Lake Okeechobee.

Based on the CEPP FWO modeling assumptions and the resulting stage reductions within Lake Okeechobee, the average annual percentage of water supply demand not met is projected to increase for the EAA and remain consistent with the ECB for the remainder of the LOSA (**Figure C.1-38**). For the eight years with the largest water supply cutbacks within the LOSA, the water supply cutback percentage is reduced for five of the eight years and increased for three of the eight years (1989, 1990, and 2001) (**Figure C.1-39**).

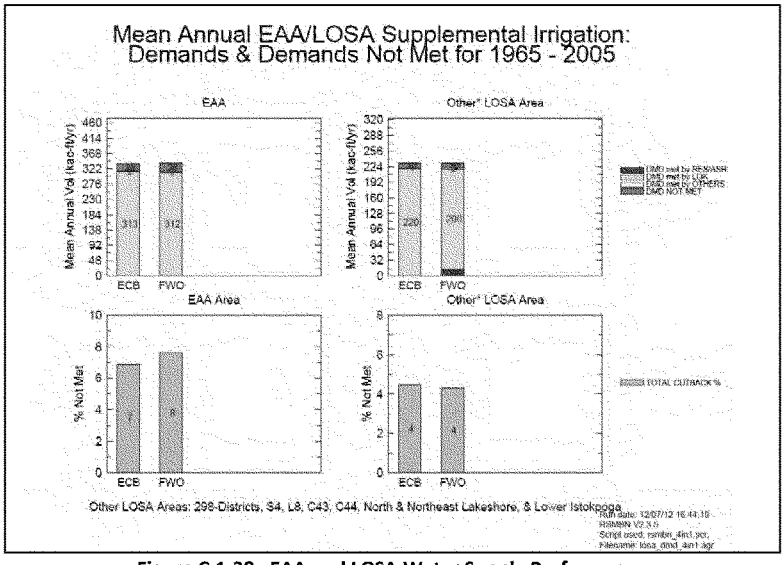


Figure C.1-38. EAA and LOSA Water Supply Performance

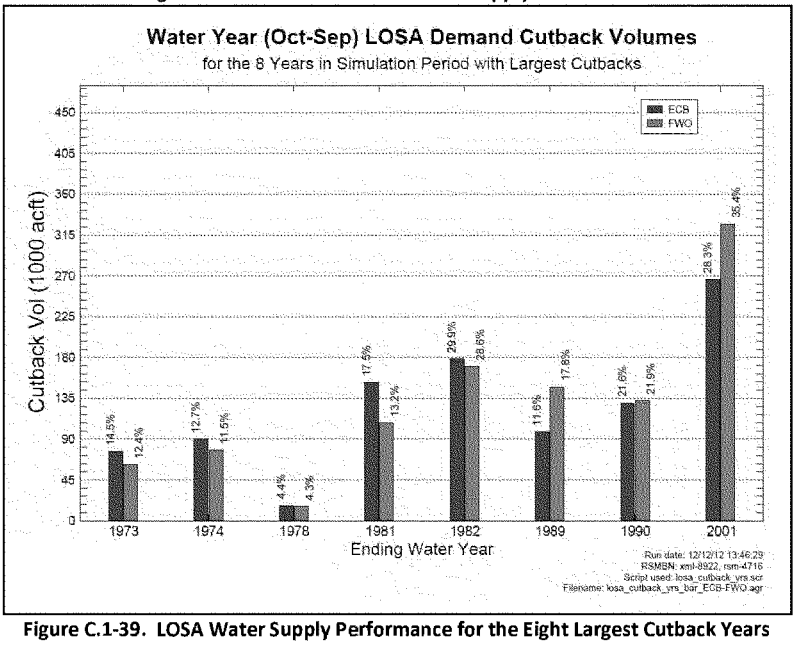


Figure C.1-39. LOSA Water Supply Performance for the Eight Largest Cutback Years

C.1.3.11.2 Seminole Tribe of Florida

Based on the CEPP FWO modeling assumptions and the resulting stage reductions within Lake Okeechobee, the percentage of water supply demand not met for the Brighton Reservation is shown to slightly increase by 0.2% (**Figure C.1-40**). The percentage of water supply demand not met for the Big Cypress Reservation is shown to be moderately reduced by 0.8% (**Figure C.1-41**). The Seminole Tribe of Florida has surface water entitlement rights pursuant to the 1987 Water Rights Compact and subsequent entitlement provisions executed between the Seminole Tribe of Florida, the State of Florida, and the SFWMD, and any potential impacts would need to be avoided or otherwise mitigated.

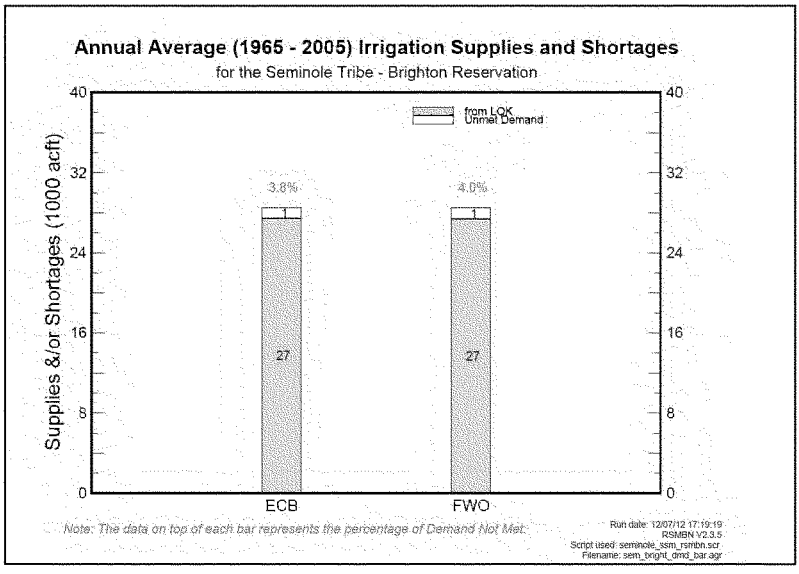


Figure C.1-40. Water Supply Demand for Seminole Tribe of Florida's Brighton Reservation

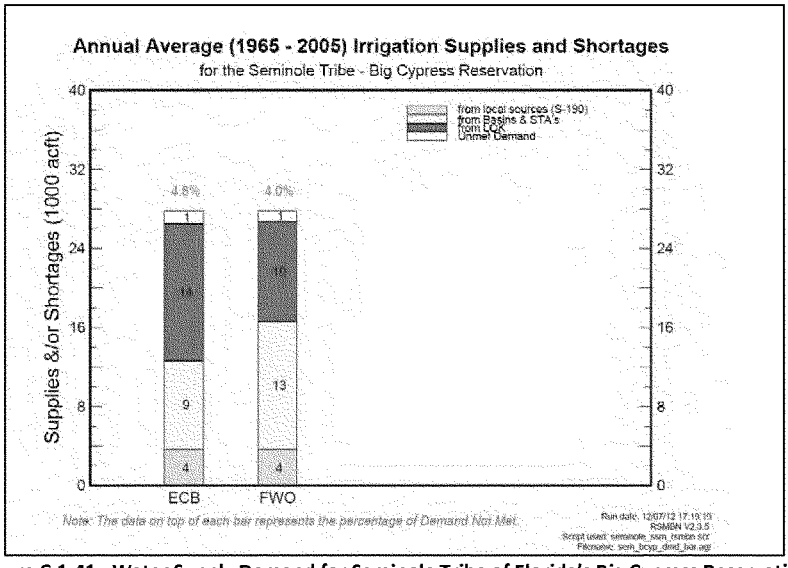


Figure C.1-41. Water Supply Demand for Seminole Tribe of Florida's Big Cypress Reservation

C.1.3.11.3 Lower East Coast Service Areas

Due to the regulatory limits on withdrawals from the SAS that affect the Everglades and WCAs, the water sources will continue to diversify. The SAS was almost the sole source of PWS in the LECSA 15 years ago. Today (2013) it supplies 94% of the PWS. The diversification of sources will continue in the future. Alternative sources include the Floridan Aquifer System, reclaimed water, storage such as ASR and surface and stormwater reservoirs, and demand management through conservation. This diversification will help to protect future supplies.

The CEPP FWO includes the combined effects from implementation of the SFWMD A-1 FEB, the ERTP WCA 3A Regulation Schedule (the CEPP ECB assumed the IOP WCA 3A Regulation Schedule), and the CERP Broward WPA Project, in addition to downstream affects associated with the stage reductions in Lake Okeechobee and reduced regulatory discharges south. The moderately reduced dry season water levels within WCA 3A, resultant from the ERTP lowering the uppermost Zone A of the WCA 3A Regulation Schedule to lower the duration and peak magnitude of wet season stages, has the potential to impact water supply for natural ecosystems and downstream uses. It is expected that this schedule will remain in place for an indeterminate period of time, although the FWS Biological Opinion for ERTP expires in 2016 and re-consultation may be required.

Despite limitations on future demand (no water supply demand increases are included in the FWO modeling), compared to the ECB, the frequency of water restrictions is projected to slightly increase for the CEPP FWO due to Lake Okeechobee falling below the Water Shortage Trigger line as defined by LOWSM: 3 additional years with 3 or more months with restrictions for LECSA 1; 1 additional years with 3 or more months with restrictions for LECSA 2; and 3 additional years with 3 or more months with restrictions for LECSA 3.

The CEPP FWO modeling also indicates changes to regional groundwater conditions within the LECSA, as compared to the CEPP ECB modeling. Despite limitations on future demand, compared to the ECB local groundwater stages east of WCA-1 at PB-1576 (LECSA 1) are expected to decline by 0.2-0.5 feet for the driest 10% of hydrologic conditions (**Figure C.1-42**). Local groundwater stages south of the Site 1 CERP project (G-2739) may be reduced by 0.2 feet for normal to dry conditions and by up to 1.0 feet during extreme dry conditions (**Figure C.1-43**). Within LECSA 2, local groundwater stages are slightly reduced by for the driest 10% of hydrologic conditions. In Miami-Dade County (LECSA 3), L-30 canal stages may be reduced by 0.2-0.4 feet for normal to extreme dry conditions (**Figure C.1-44**); L-31N canal stages may be slightly reduced by 0.1-0.2 feet for extreme dry conditions (**Figure C.1-45**); and C-111 canal stages between S-176 and S-18C are generally lowered by 0.2-0.5 feet for normal to extreme dry conditions (**Figure C.1-46**). Reduced groundwater stages may result in increased water supply demands on the regional system, particularly Lake Okeechobee, to manage canal levels within the target range to prevent saltwater intrusion.

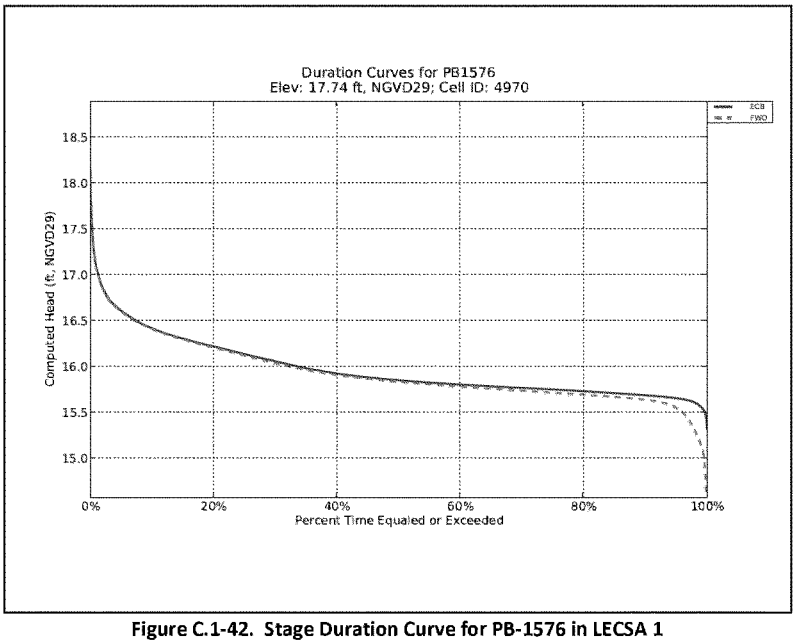


Figure C.1-42. Stage Duration Curve for PB-1576 in LECSA 1

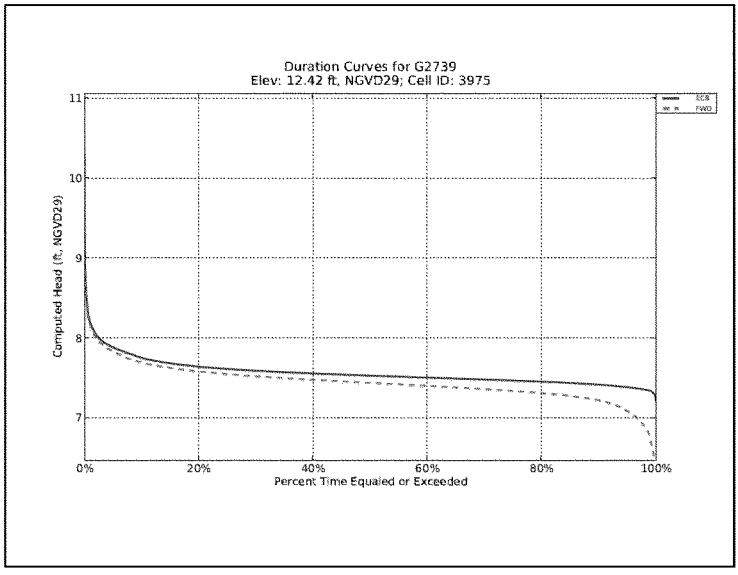


Figure C.1-43. Stage Duration Curve for G-2739 in LECSA 1

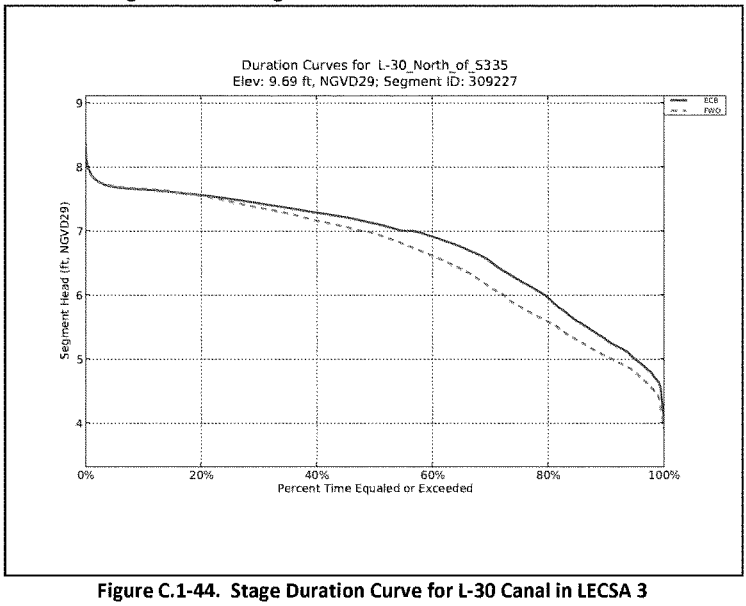


Figure C.1-44. Stage Duration Curve for L-30 Canal in LECSA 3

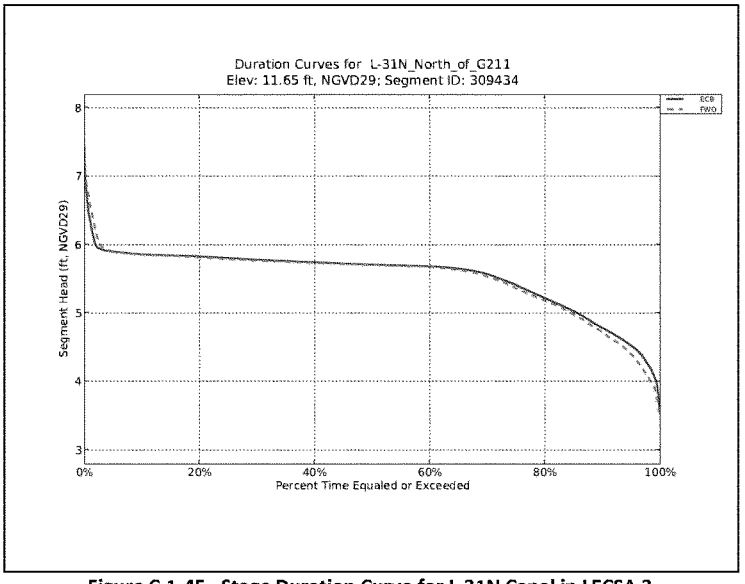


Figure C.1-45. Stage Duration Curve for L-31N Canal in LECSA 3

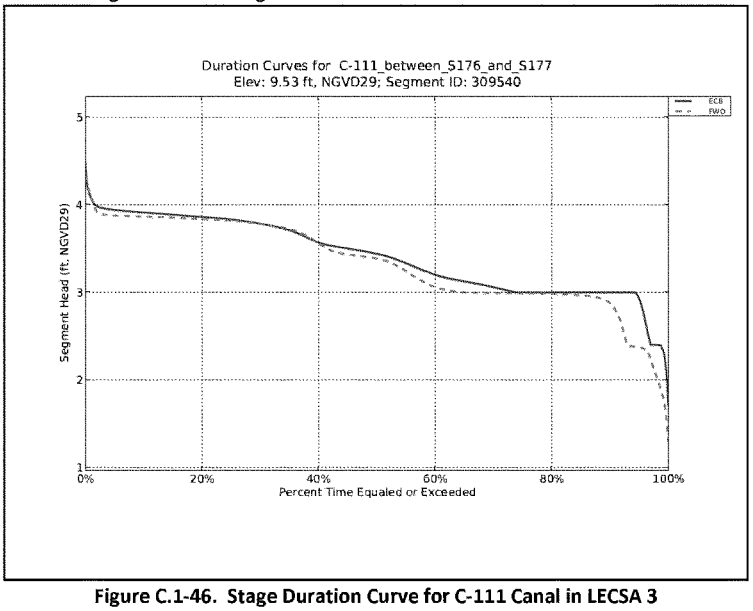


Figure C.1-46. Stage Duration Curve for C-111 Canal in LECSA 3

C.1.3.12 Water Quality

The two most significant water quality issues within the study area are associated with nutrient pollution and the bioaccumulation of mercury by fish and birds. General discussion of the phosphorus issues within the basin are provided here. More detained discussions on phosphorous can be found in **Annex F**.

C.1.3.12.1 Lake Okeechobee

Water quality in Lake Okeechobee should improve under the FWO condition relative to the existing conditions as a result of implementation of TMDLs and associated BMAPs within the Upper Kissimmee River Basin as well as lake basin. The State of Florida has committed to achieving the phosphorus TMDL for the lake by implementing a series of source controls and treatment facilities within the basin. Achieving the TP load TMDL for the lake of 140 tons/year will result in improved dissolved oxygen conditions and reduced incidence of algal blooms.

Mercury methylation conditions within the lake should improve due to the implementation of the proposed mercury TMDL for Florida; however, the greatest reduction in methylated mercury will only come about through international controls on atmospheric emissions of mercury related to the combustion of coal and other fuels.

C.1.3.12.2 Northern Estuaries

Nutrient and dissolved oxygen conditions should improve during the wet season within the Caloosahatchee River and Estuary given the reduction in high flow events due to implementation of the C-43 Reservoir Project (USACE 2010). The frequency of dry season algal events within the upper estuary may decrease as a result of increased dry season flows through the S-79 structure during the late spring due to implementation of the C-43 Reservoir Project (USACE 2010).

Nutrient and dissolved oxygen conditions should improve during the wet season within the St. Lucie Estuary given the reduction in high flow events due to implementation of the Indian River Lagoon South Project (USACE 2004a). Low flow event conditions do not change significantly within the St. Lucie for FWO conditions; therefore no change to water quality is expected during the dry season. Mercury methylation conditions within the estuaries should improve due to the implementation of the proposed mercury TMDL for Florida; however, the greatest reduction in methylated mercury will only come about through international controls on atmospheric emissions of mercury related to the combustion of coal and other fuels.

C.1.3.12.3 Everglades Agricultural Area

Nutrient and sulfate loading into the EAA and from interbasin transfers (such as from Lake Okeechobee) should decrease as a result of the implementation of TMDLs and BMPs. Implementation of the SFWMD's Restoration Strategies program which includes the construction of additional STA treatment and storage capacity will increase removal of nutrients and sulfate and decrease loading to the downstream Everglades. Water quality modeling done using the Dynamic Model for Stormwater Treatment Areas (DMSTA) indicates that implementation of the Restoration Strategies program will result in meeting the 2012 WQBEL (Water Quality Based Effluent Limit) which is defined as 1) not to exceed 13 ppb AFWM (annual flow-weighted mean) in more than 3 out of 5 years, and not to exceed 19 ppb AFWM in any given year. The WQBEL is applied at the discharge of each individual STA. The cessation of agricultural activities on the A-1 FEB lands and other U.S. Sugar Lands purchased by the SFWMD will result in the reduction of sulfate loads downstream due to reduced soil oxidation and

reduced sulfate loading on those lands. Construction of the A-1 FEB may cause a short-term release of methylated mercury; however, monitoring during the start up phase should minimize this.

C.1.3.12.4 Greater Everglades

Mercury methylation will continue to be a problem within the Greater Everglades in the FWO condition. The implementation of new mercury emission criteria by the USEPA and FDEP will reduce locally sourced mercury deposition; however, internationally sourced airborne mercury sources from developing countries such as Brazil, India, and China are not projected to decrease.

C.1.3.12.4.1 Water Conservation Areas 1 and 2

Water quality conditions for the FWO should be improved in WCA 1 and WCA 2 relative to the existing baseline condition because the implementation of the SFWMD's Restoration Strategies features will reduce TP loads into these areas. Reduced sulfate loading is likely to somewhat alter the areas where mercury methylation is problematic within WCA 2.

C.1.3.12.4.2 Water Conservation Area 3A

Nutrient and sulfate concentrations and loads for WCA 3A for the FWO condition should decrease relative to the existing baseline condition because of the implementation of the SFWMD's Restoration Strategies features within the central flow path of the EAA. The reduction in nutrient loads to WCA 3A should reduce the rate at which native vegetation within the marsh is replaced by ecologically less desirable cattails. A summary of the existing nutrient conditions within WCA 3A is found in **Annex F**.

Given the complexity of the methylmercury cycle, it is not possible to predict with certainty the effect of future hydrology and mercury/sulfate loading on methylmercury formation and bioaccumulation. It is likely that some areas of WCA 3A will see higher mosquitofish mercury concentrations while other areas will see lower mosquitofish mercury concentrations. Given the reduction in atmospheric mercury deposition over the last 15 years which is thought to be the cause of the reduction in bioaccumulated mercury observed in fish over this time period, it is likely that future methylation and bioaccumulation of mercury will not exceed the peak concentrations seen 15 or so years ago unless atmospheric mercury loading increases.

C.1.3.12.4.3 Water Conservation Area 3B

The FWO alternative should have some improvement in WCA 3B water quality given the expected reduction in nutrient loading from the EAA and the S-9 basin. However, increased severity of dryout events due to shortened hydroperiods as a result of water management practices is likely to result in additional marsh fire events. Fire events re-mobilize soil bound pollutants and temporarily degrade water quality by increasing water column TP and possibly increasing methylmercury formation. The effects of increased dry events on column methylmercury concentrations and total mercury body burden in fish and birds in WCA 3B cannot be predicted with certainty, though it is probable given recent downward trends in measured mercury concentrations in this area that the FWO condition is not likely to result in bioaccumulation that exceeds historic concentration maximums unless atmospheric mercury loads increase from present levels.

C.1.3.12.4.4 Everglades National Park

The quality of water entering SRS under the FWO condition should be improved relative to the baseline condition given the additional treatment capacity provided in the EAA and in the S-9 basin. Discharges from WCA 3A into SRS are more likely to meet the applicable TP criteria under the FWO condition than under baseline conditions. Sulfate concentrations in water discharged to Shark River Slough should be

lower under the FWO condition than present condition given the additional removal of sulfate that will result from the expansion of STAs and construction of the A-1 FEB.

C.1.3.13 Air Quality

During the period between the present and 2072, air quality is expected to be degraded due to increased populations and urbanization. Air quality is expected to comply with air quality standards; however it is possible that regions of the project area may be classified as air quality non-attainment zones.

C.1.3.14 Hazardous, Toxic and Radioactive Wastes

The HTRW conditions under the future without project condition are expected to be very similar to the present condition. Farming operations and the accompanying HTRW contamination would continue on the A-2 FEB lands for the foreseeable future until the overlying peat soils are exhausted due to oxidation. HTRW contamination and cleanup will continue at present rates given continued agricultural, residential, and commercial use of other lands within the study area.

C.1.3.15 Cultural Resources

The conditions under the FWO conditions are expected to be very similar to the existing conditions. Farming operations would continue in EAA A-2 lands, causing adverse effects to two significant cultural resource sites. Under ERTP operations, stages are generally decreased in southern WCA 3A, therefore having a beneficial effect to tree islands currently occupied by members of the Miccosukee Tribe of Indians of Florida. Investigations mandated by the ERTP Programmatic Agreement would completed in ca. 2016 resulting in a determination of effects of fluctuating water on subsurface cultural material throughout the Everglades ecosystem. Future research will be needed to determine if prolonged dry down events in areas such as northern WCA 3A and WCA 3B adversely affects archaeological sites.

All state owned and/or managed state lands, including cultural resources within those lands would be managed as described in F.S. 267.061(2) and management plans developed in consultation with the Florida Division of Historic Resources. See Appendix G in "A Conceptual Management Plan for The Everglades Complex of Wildlife Management Areas" at http://myfwc.com/conservation/terrestrial/management-plans/online-mps/. Cultural Resources within National Park Service Lands would be managed in accordance to Federal laws and pre-established management plans for resources under National Park Service jurisdiction.

C.1.3.16 Socioeconomics

The 2010 Census count of total population as reported by the United States Census Bureau is the basis for the 2010 population estimates as reported by the University of Florida's Bureau of Economic and Business Research (BEBR). The 2010 BEBR estimates for permanent resident population (BEBR 2011) are the basis for estimating 2030 populations for each county in the LEC. **Table C.1-12** provides BEBR population projections for the low, medium, and high ranges for 2015–2040 for the LEC Planning Area.

Table C.1-12. BEBR Population Projections for the LEC Planning Area for 2010-2040.

	Projections					
	2015	2020	2025	2030	2035	2040
Palm Beach County						
Low	1,342,600	1,367,700	1,383,900	1,389,700	1,384,900	1,370,900
Medium	1,394,300	1,482,900	1,568,500	1,648,000	1,720,000	1,786,000
High	1,454,500	1,605,600	1,761,400	1,919,200	2,077,300	2,236,700
Broward County						
Low	1,736,800	1,726,300	1,710,600	1,689,000	1,661,600	1,632,900
Medium	1,788,200	1,834,500	1,877,700	1,916,200	1,949,700	1,982,500
High	1,844,200	1,946,700	2,048,900	2,149,600	2,248,100	2,349,700
Miami-Dade County						
Low	2,528,700	2,564,400	2,590,900	2,606,400	2,610,300	2,604,100
Medium	2,600,900	2,722,900	2,841,400	2,952,800	3,055,100	3,150,200
High	2,685,100	2,891,800	3,103,400	3,317,200	3,531,500	3,747,400

C.1.3.17 Land Use

The region, including cities within the study area, is expected to continue to grow both in population and in the development that population demands. Florida is expected to grow at a rate exceeding the national expected growth rate. But the growth rate is expected to diminish in the future. This is consistent with the concept of urban sprawl. As most highly demanded real estate is developed and an area becomes built out, its ability or willingness to absorb additional population growth through more intense methods of development becomes limited. Counties that have traditionally grown at a rate exceeding the state growth rate will slow, and the most intense future population growth will occur in other counties. Growth beyond available developable land will require changes in land use and possible rezoning of existing land. Urban or commercial development should occur within major urban service areas located within the project area. Agriculture is expected to remain a strong economic force, yet conceding some ground to urban development and conservation efforts. It is not anticipated that land use acreages will increase or decrease substantially.

C.1.3.18 Recreation

In general, the variety of recreational interests in the United States appears to be increasing along with recreational participation rates. As future recreation needs and interests develop, it is important to recognize that participation in specific types of recreational activities is often linked to demographic factors such as age and income. For example, participation in activities requiring vigorous exercise is considerably higher for young people than for senior citizens. However, the elderly population is increasing recreation participation because of the growing awareness of the importance of physical fitness. Participation in most activities is low for those with family incomes below $25,000 per year. Interestingly, participation is low for those with family incomes greater than $100,000 per year. Most outdoor recreational activities appear to be enjoyed largely by the middle class, those with family incomes between $25,000 and $75,000 per year.

The State Comprehensive Outdoor Recreation Plan (SCORP) is the best source of information on recreation demand and supply at the state and regional scales. The SCORP organizes outdoor recreation in Florida into 47 categories that encompass a variety of recreation activities including team sports (e.g., basketball and baseball), individual sports (e.g., golf and tennis), hunting, fishing, swimming and boating. Recreation demands were developed for the SCORP through surveys of residents and tourists. Participation in outdoor recreation activities is expressed in terms of user-occasions, which occur each time an individual participates in a single outdoor recreation activity.

The number of user-occasions was calculated for each planning region as well as the entire state by type of activity. Demand was estimated for 2000, 2007, 2010, 2015 and 2020 by applying the per capita participation rates to population projections. **Table C.1-13** presents Year 2007 and projected Year 2015 demands for the selected recreation activities in SCORP Planning Regions Treasure Coast and south Florida. This table includes user- occasions as well as facility/resource needs. As part of the without project conditions, all of the regions are expected to have significant increases in demands for the selected recreation activities with a commensurate need to increase development of the regions' recreation resources and facilities.

Table C.1-13. Demand and Facility Needs (2007 and 2015) Selected Recreation Activities

Activity	Units	Demand (user-occasions)		Additional Facility Needs	
		2007	2015	2007	2015
Hunting	Acres	663,841	772,849	1,041,817	100,137
RV/Trailer Camping	Camp Sites	2,203,445	2,779,565	19,278	2,231
Tent Camping	Camp Sites	888,761	1,136,981	2,094	223
Bicycling	Miles	1,502,910	1,644,911	247	29
Hiking	Miles	1,282,041	1,672,767	812	99
Horseback Riding	Miles	1,780,575	2,189,849	302	33
Nature Study	Miles	1,456,739	1,988,143	371	46
Canoeing	N/A.	108,405	142,253	357	not estimated
Freshwater Boat Ramps	Lanes	559,201	620,305	247	26
Freshwater Bank Fishing	Feet	711,215	786,890	15,755	2,801

C.1.3.19 Noise

Sources of noise associated with surrounding land use are expected to be similar to those described in existing conditions. During the period between the present and the year 2072, noise within the major natural areas of south Florida would continue to be limited and of low occurrence. Noise levels would be expected to change where land use is projected to change. Within rural municipalities and urban areas, sound levels would be expected to be of greater intensity, frequency, and duration as areas are further developed in 2072 from agricultural to residential/commercial due to increased noise from traffic, construction associated with development, and increased operations at commercial and industrial facilities.

C.1.3.20 Aesthetics

Sources of visual aesthetics are expected to be similar to those described in existing conditions. Visual characteristics would be expected to change where land use is projected to change. During the period between the present and the year 2072 the visual environment within the major natural areas of south Florida, is expected to decline as changes in the availability and distribution of freshwater would further exacerbate changes occurring in fish and wildlife resources and vegetative communities as described in **Sections C.1.2.1** and **C.1.2.2**. Within rural municipalities and urban areas, the occurrence of visible topographic features would be expected to be of greater occurrence as areas are further developed in 2072 from agricultural to residential/commercial. Increased occurrence of visible topographic features (i.e. heavily used roads, highways, single-family homes, high rises, commercial and industrial facilities) may detract from the regional aesthetic.

C.1.4 FUTURE WITHOUT PROJECT CONDITIONS OF NATIVE AMERICANS

The Miccosukee Tribe of Indians of Florida and the Seminole Tribe of Florida would continue to rely upon the Everglades in its natural state to support their religious, subsistence, and commercial activities. Changes in the availability and distribution of freshwater and further disruption of natural water sheetflow due to levees, roads, and canals would further exacerbate changes occurring in the Greater Everglades. Although under ERTP, some areas within southern WCA 3A show improvement, the continuation of altered hydroperiods would have adverse effects on vegetative communities and fish and wildlife resources such as degradation due to over drying within northern WCA 3A, WCA 3B, and ENP, and ponding and prolonged high water levels within southern WCA 3A. Therefore the religious, subsistence, and commercial activities have the potential to be affected by the changing environment due to the above stated potential changes to the Everglades.

C.1.5 REFERENCES

Armentano, T.V., J.P. Sah, M.S. Ross, D.T. Jones, H.C. Colley, and C.S. Smith. 2006. Rapid responses of vegetation to hydrological changes in Taylor Slough, Everglades National Park, Florida. Hydrobiologia 569:293-309.

Bancroft, G.T., A.M. Strong, R.J. Sawicki, W. Hoffman, and S.D. Jewell. 1994. Relationships among wading bird foraging patterns, colony locations, and hydrology in the Everglades. Pages 615-657, *in* Everglades: The Ecosystem and Its Restoration, S.M. Davis and J.C. Ogden (Eds.). St. Lucie Press, Delray Beach, Florida.

Bernhardt, C.E. and D.A. Williard. 2006. Marl prairie vegetation response to 20th century hydrologic change. U.S. Geological Survey Open-File Report 2006-1355. U.S. Geological Survey, Eastern Earth Surface Processes Team, 926A National Center, Reston, Virginia, Florida.

Bloom, N.S. 1992. On the chemical form of mercury in edible fish and marine invertebrate tissue. Canadian Journal of Fisheries and Aquatic Sciences, 49(5):1010-1017.

Bourn, W.S. 1932. Ecological and physiological studies on certain aquatic angiosperms. Contribution of the Boyce Tompson Institute 4:425-496

Burns, K., J. Gannon, C. Weaver, E. Estevez, A. Boyes and M. Gittler. 2007. SAV and faunal relationships with regard to salinity and seasonality. Mote Marine Laboratory Technical Report 1199 to the South Florida Water Management District. West Palm Beach, Florida.

Calanca, P. A. Roesch, K. Jasper and M. Wild. 2006. Global warming and the summertime evapotranspiration regime of the Alpine region. Climate Change 79:65-78.

Chamberlain, R.H. and P.H. Doering. 1998a. Preliminary estimate of optimum freshwater inflow to the Caloosahatchee Estuary: a resource-based approach. Pages 121–130 *in* Proceedings of the Charlotte Harbor Public Conference and Technical Symposium 1997 March 15-16, Punta Gorda, Florida, Charlotte Harbor National Estuary Program Technical Report No. 98-02, S.F. Treat (ed). West Palm Beach, Florida.

Chamberlain, R.H. and P. H. Doering. 1998b. Freshwater inflow to the Caloosahatchee Estuary and the resource-based method for evaluation. Pages 81–90 *in* Proceedings of the Charlotte Harbor Public Conference and Technical Symposium 1997 March 15-16, Punta Gorda, Florida, Charlotte Harbor National Estuary Program Technical Report No. 98-02, S.F. Treat (ed). West Palm Beach, Florida.

Cuda, J.P. 2009. Invasive species a Florida perspective. Entomology and Nematology Department, University of Florida, Institute of Food and Agricultural Sciences.

Cunningham, K.J., Wacker, M.A., Robinson, E., Dixon, J.F., and Wingard, G.L.. 2006. A cyclostratigraphic and borehole-geophysical approach to development of a three-dimensional conceptual hydrogeologic model of the karstic Biscayne Aquifer, southeastern Florida. US Geological Survey Scientific Investigations Report 2005-5235.

Cunningham, K.J. and Sukop, M.C. 2011. Multiple technologies applied to characterization of the porosity and permeability of the Biscayne Aquifer, Florida. US Geological Survey Open-File Report 2011-1037, Accessed at http://pubs.usgs.gov/of/2011/1037/

Craft, C. B. and C. Richardson. 2007. Soil Characteristics of the Everglades peatland. Page 59, *in* The Everglades Experiments, Richardson (Ed). Springer 2008.

Corrales J, et. al 2011, Sulfate threshold target to control methylmercury levels in wetland ecosystems, Sci Total Environ, (2011). http://dx.doi.org/10.1016/j.scitotenv.2011.02.030

Davis, S.M. and J.C. Ogden. 1997. Everglades: the Ecosystem and its Restoration. St. Lucie Press, Delray Beach, Florida.

Dawes, C.J., D. Hanisak and W.J. Kenworthy. 1995. Seagrass biodiversity in the Indian River Lagoon. Bulletin of Marine Sciences 57(1):59-66.

Doering, P.H., R.H. Chamberlain, K.M. Donohue and A.D. Steinman. 1999. Effect of salinity on the growth of *Vallisneria americana* from the Caloosahatchee Estuary, Florida. Florida Scientist. 62(2):89-105.

Doering, P.H., R.H. Chamberlain and J.M. McMunigal. 2001. Effects of simulated saltwater intrusions on the growth and survival of wild celery, *Vallisneria americana*, from the Caloosahatchee Estuary (South Florida). Estuaries 24(6A):894-903.

DOI. 2010. Tamiami Trail Modifications: Next Steps Project Final Environmental Impact Statement. United States Department of the Interior. Everglades National Park, Florida.

Doren, R.F., A.P. Ferriter, and H. Hastings (Eds.). 2001. Weeds won't wait!: The strategic plan for managing Florida's invasive exotic plants, part one: an assessment of invasive plants in Florida. A report to the South Florida Ecosystem Restoration Task Force and Working Group, Florida.

Duever, M.J., J.F. Meeder, L.C. Meeder, and J.M. McCollom. 1994. The climate of south Florida and its role in shaping the Everglades ecosystem. Pp. 225-248 *in* Everglades: The Ecosystem and Its Restoration, S.M. Davis and J.C. Ogden (Eds.). St. Lucie Press, Delray Beach, Florida.

Fish, J.E. and Stewart, M.A. 1991. Hydrogeology of the surficial aquifer system, Dade County, Florida. US Geological Survey Water Resources Investigations Report.

Fleming, L. E., Watkins, S., Kaderman, R., Levin, B., Ayyar, D. R., Bizzio, M., ... & Bean, J. A. (1995). Mercury exposure in humans through food consumption from the Everglades of Florida. In Mercury as a Global Pollutant (pp. 41-48). Springer Netherlands.

Florida Atlantic University Center for Environmental Studies. 2013. Final Report, Predicting Ecological Changes in the Florida Everglades under a Future Climate Scenario. Florida Atlantic University, Boca Raton, FL. http://www.ces.fau.edu/climate_change/ecology-february-2013/PECFEFCS_Report.pdf

Florida Department of Environmental Protection. 2010. Division of Air Resource Management. Bureau of Air Monitoring and Mobile Sources Air Monitoring Report. Tallahassee, Florida.

Florida Department of Health, 2013. Fish Advisory List. http://www.doh.state.fl.us/floridafishadvice/Working.html

Florida Fish and Wildlife Conservation Commission. 2007. A conceptual management plan for the Everglades complex of wildlife management areas (Everglades/Francis S. Taylor, Holy Land and Rotenberger Wildlife Management Areas). 2002-2007.

Florida Oceans and Coastal Council. 2009. The effects of climate change on Florida's ocean and coastal resources. Tallahassee, FL. 34 pp.

French, G.T. and K.A. Moore. 2003. Single and interactive effects of light and salinity stress on the growth, reproduction and photosynthetic capabilities of *Vallisneria americana*. Estuaries 26:1255-1268.

Grieb, T.M., C.T. Driscoll, S.P. Gloss, C.L. Schofield, G.L. Bowie and D.B. Porcella. 1990. Factors affecting mercury accumulation in fish in the upper Michigan peninsula. Environmental Toxicology and Chemistry, 9(7):919-930.

Gunderson, L.H., C.S. Holling, G. Peterson, and L. Pritchard. 1997. Resilience in ecosystems, institutions and societies. Beijer Discussion Paper Number 92, Bejer International Institute for Ecological Economics, Stockholm, Sweden.

Haller, W.T. 1974. The Photosynthetic characteristics of the submersed aquatic plants Hydrilla, Southern Naiad, and Vallisneria. Ph.D. dissertation. University of Florida, Gainesville, Florida.

Havens, K. E. and W.W. Walker. 2002. Development of a total phosphorus concentration goal in the TMDL process for Lake Okeechobee, Florida (USA). Lake and Reservoir Management. 18:227-238.

Hoffacker, V.A. 1994. Caloosahatchee River Submerged Grass Observation during 1993. W. Dexter Bender and Associates, Inc. Letter report and map to South Florida Water Management District, West Palm Beach, Florida.

IRL CCMP. 1996. Indian River Lagoon comprehensive conservation and management plan. Sponsored by the St. Johns River Water Management District and South Florida Water Management District in cooperation with the U.S. Environmental Protection Agency. Indian River Lagoon National Estuary Program, Melbourne, Florida.

Irlandi, E. 2006. Literature review of salinity effects on submerged aquatic vegetation found in the southern Indian River Lagoon and adjacent estuaries. South Florida Water Management District, West Palm Beach, Florida.

International Panel on Climate Change. 2007. Climate Change 2007 – The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the IPCC. Cambridge Univ. Press.

James, R.T and P.V. McCormick. 2012. The sulfate budget of a shallow subtropical lake. Fundamentals of Applied Limnology 181(4):263-269.

Jarvis, J.C. and K.A. Moore. 2008. Influence of environmental factors on the seed ecology of Vallisneria americana. Aquatic Botany 88:283-294.

Johnson, J. 2012. Estimating the Vulnerability of Everglades Peat to Combustion. Master's Thesis, Environmental Sciences Program, Florida Atlantic University.

Julian II, P., G. Payne and S. Xue. 2013. Chapter 3A: Status of Water Quality in the Everglades Protection Area. In: 2013 South Florida Environmental Report – Volume I, South Florida Water Management District, West Palm Beach, FL.

Julian, P. 2013. Mercury bioconcentration factor in Moquitofish (Gambusia spp.) in the Florida Everglades. Bulletin of Environmental Contamination and Toxicity, 90(3):329-332.

Julian, P., B. Gu, R. Fydenborg, T. Lange, A.L. Wright and J.M. McCray. 2014. Chapter 3B: Mercury and Sulfur Environmental Assessment for the Everglades. In: 2014 South Florida Environmental Report – Volume I. South Florida Water Management District, West Palm Beach, FL, USA.

Kraemer, G.P., R.H. Chamberlain, P.H. Doering, A.D. Steinman and M.D. Hanisak. 1999. Physiological responses of Vallisneria americana transplants along a salinity gradient in the Caloosahatchee Estuary (SW Florida). Estuaries 22:138-148.

Krabbenhoft, D. P. and E, M. Sunderland. 2013. Global Change and Mercury. Science 341: 1457-1458.

Lockwood, J.L., B. Baiser, R.L. Boulton, and M.J. Davis. 2006. Detailed study of Cape Sable seaside sparrow nest success and causes of nest failure. Annual Report. U.S. Fish and Wildlife Service, Vero Beach, Florida.

Maul, G.A. and Martin, D.M. 1993. Sea level rise at Key West, Florida, 1846-1992, America's longest instrument record. Geophysical Research Letters 20(8).

Milanich, J.T. 1994. Archaeology of Precolumbian Florida. University Press of Florida.

Miller, J.A. 1990. Ground water atlas of the United States, Segment 6, Alabama, Florida, Georgia, and South Carolina. US Geological Survey Hydrologic Investigations Atlas 730-G, 28 p.

McVoy, C., W.P. Said, J. Obeysekera, J. VanArman, and T.W. Dreschel. 2011. Landscapes and Hydrology of the Predrainage Everglades. South Florida Water Management District, Gainesville, Florida: University Press of Florida.

Milleson, J.T. 1987. Vegetation changes in the Lake Okeechobee littoral zone 1972-1982. Technical Publication No.97-3. South Florida Water Management District. West Palm Beach, Florida.

Mitchell, C. P., Branfireun, B. A., & Kolka, R. K. 2008a. Assessing sulfate and carbon controls on net methylmercury production in peatlands: An in situ mesocosm approach. *Applied Geochemistry, 23*(3), 503-518.

Mitchell, C. P., Branfireun, B. A., & Kolka, R. K. 2008b. Spatial characteristics of net methylmercury production hot spots in peatlands. *Environmental Science & technology*, *42*(4), 1010-1016.

Morris, L.J., R.W. Virnstein, J.D. Miller and L.M. Hall. 2000. Monitoring seagrass changes in Indian River Lagoon, Florida using fixed transects. Pages 167-176 *in* Seagrasses: Monitoring, Ecology, Physiology, and Management, S.A. Bortone (ed), CRC Press, Boca Raton, Florida.

NOAA. 2001. Sea level variations of the United States 1854-1999. National Atmospheric Oceanic Administration Technical Report NOS CO-OPS 36.

NMFS. 2000. Essential fish habitat: new marine fish habitat conservation mandate for federal agencies. National Marine Fisheries Service Habitat Conservation Division Southeast Regional Office. St. Petersburg, Florida.

Obeysekera J., Irizarry M., Park J., Barnes J., and T. Dessalegne. 2011. Climate change and its implication for water resources management in South Florida, Journal of Stochastic Environmental Research & Risk Assessment, 25(4), 495.

Orem, B. 2013. Email to Mark Shafer on 1/31/2013 from Bill Orem, United States Geological Survey. Reston, VA.

Patterson, K., and R. Finck. 1999. Tree Islands of the WCA3 aerial photointerpretation and trend analysis project summary report. St. Petersburg, Florida: Geonex Corporation. Report to the South Florida Water Management District.

RECOVER. 2009. 2009 System status report. Restoration Coordination and Verification Program c/o United States Army Corps of Engineers, Jacksonville, Florida, and South Florida Water Management District, West Palm Beach, Florida.

Reese, R.S. and Cunningham, K.J. 2000. Hydrogeology of the gray limestone aquifer in southern Florida. U.S. Geological survey Water Resources Investigations Report. Pages 99-4213.

Reese, R.S. and Wacker, M.A. 2009. Hydrogeologic and hydraulic characterization of the surficial aquifer system, and origin of high salinity groundwater, Palm Beach County, Florida. US Geological Survey Scientific Investigations Report 2009-5113, 42 pages plus CD. Available for download at http://pubs.usgs.gov/sir/2009/5113/

Renken, R.A., Cunningham, K.J., Shapiro, A.M., Harvey, R.W., Zygnerski, M.R., Metge, D.W., and Wacker, M.A. 2008. Pathogen and chemical transport in the karst limestone of the Biscayne aquifer: 1. Revised conceptualization of groundwater flow. Water Resources Research, 44, W08429, doi:10.1029/2007WR006058. http://www.agu.org/pubs/crossref/2008/2007WR006058.shtml

Ross, M.S., J.P. Sah, J.R. Snyder, P.I. Ruiz, D.T. Jones, H. Colley, R. Trabieso and D. Hagayari. 2006. Effect of hydrology restoration on the habitat of the Cape Sable seaside sparrow. Annual report of 2005-2005. Unpublished report to the U.S. Army Corps of Engineers, Jacksonville, Florida. Southeast Environmental Research Center, Florida International University, Miami, Florida.

Rumbold, D. G., & Fink, L. E. (2006). Extreme spatial variability and unprecedented methylmercury concentrations within a constructed wetland. Environmental Monitoring and Assessment, 112(1-3), 115-135.

Seminole Tribe of Florida, 2013. History. http://www.semtribe.com/History/. Accessed on January 09, 2013.

Sklar, F. and A. van der Valk, eds. 2002. Tree islands of the Everglades: an overview. Pages. 1-18 *in* Tree Islands of the Everglades. Kluwer Academic Publishers, Dordrecht, The Netherlands.

SFWMD. 2011a. Lake Okeechobee Protection Plan. South Florida Water Management District, West Palm Beach, Florida

SFWMD. 2011b. South Florida Environmental Report. South Florida Water Management District, West Palm Beach, Florida.

SFWMD. October 2012a. Basis of Review for Water Use Permit Applications within the South Florida Water Management District, West Palm Beach, Florida.

http://www.sfwmd.gov/portal/page/portal/xweb%20-%20release%202/rules%20statutes%20and%20criteria.

SFWMD. 2012b. South Florida Environmental Report. South Florida Water Management District, West Palm Beach, Florida.

SFWMD. 2012c. South Florida Water Management District Restoration Strategies. South Florida Water Management District, West Palm Beach, Florida. http://www.sfwmd.gov/portal/page/portal/xweb%20protecting%20and%20restoring/restoration%20strategies

SFWMD. 2013. South Florida Environmental Report South Florida Water Management District, West Palm Beach, Florida.

Steele, Willard. n.d. Who are the Seminole People?. Accessed at http://www.ahtahthiki.com/History-Seminole-Tribe-FL-Ah-Tah-Thi-Ki-Museum.html. Accessed on January 09, 2013.

Stein, B.A., L.S. Kutner, and J.S. Adams (Eds.). 2000. Precious heritage: the status of biodiversity in the United States. Oxford University Press, Oxford, England.

Tchounwou, P. B., Ayensu, W. K., Ninashvili, N., & Sutton, D. (2003). Review: Environmental exposure to mercury and its toxicopathologic implications for public health. *Environmental Toxicology*, *18*(3), 149-175.

Thomas, T.M. 1974. A detailed analysis of climatological and hydrological records of South Florida with reference to man's influence upon ecosystem evolution. Pages 81-122 *in* Environments of South Florida: Present and Past, Memoir No. 2, P.J. Gleason (ed). Coral Gables, Florida.

Thompson, M.J. 1978. Species composition and distribution of seagrass beds in the Indian River Lagoon, Florida. Florida Scientist 41(2):90-96.

Troxler, T.G., and D.L. Childers. 2010. Biogeochemical contributions of tree islands to Everglades wetland landscape nitrogen cycling during seasonal inundation. Ecosystems 13:75-89.

Twilley, R.R., E.J. Barron, H.L. Gholz, M.A. Harwell, R.L. Miller, D.J. Reed, J.B. Rose, E.H. Siemann, R.G. Wetzel and R.J. Zimmerman. 2001. Confronting Climate Change in the Gulf Coast Region. A report of the Union of Concerned Scientists and the Ecological Society of America.

Union of Concerned Scientists. 2008. National Headquarters, 2 Brattle Square, Cambridge, Massachusetts 02238-9105 http://www.ucsusa.org/gulf/gcstateflo_cli.html.

USACE. 1991. Central and Southern Florida Project for flood Control and Other Purposes, Environmental Restoration of the Kissimmee River, Florida, Final integrated Feasibility Report and Environmental Impact Statement. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USACE. 1994. Central and Southern Florida Project for Flood Control and Other Purposes, Master Water Control Manual for Kissimmee River-Lake Istokpoga Basin. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USACE. 1996. Central and Southern Florida Project for Flood Control and Other Purposes Master Water Control Manual, Volume 4: Water Conservation Areas, Everglades National Park, and ENP-South Dade Conveyance System. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USACE. 1998. Final Environmental Impact Statement Central and Southern Florida Project, Canal 51, West End Flood Control Project. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USACE. 1999. Central and Southern Florida Project Comprehensive Review Study: Final Integrated Feasibility Report and Programmatic Environmental Impact Statement. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USACE. 2000. Central and Southern Florida Project Modified Water Deliveries to Everglades National Park, Florida: 8.5 Square Mile Area General Reevaluation Report. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USACE. 2004a. Central and Southern Florida Project: Indian River Lagoon-South Final Integrated Project Implementation Report and Environmental Impact Statement. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USACE. 2004b. Comprehensive Everglades Restoration Plan Picayune Strand Restoration (Formerly Southern Golden Gate Estates Ecosystem Restoration) Final Integrated Project Implementation Report and Environmental Impact Statement. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USACE. 2005. Final Environmental Impact Statement for the Herbert Hoover Dike Major Rehabilitation Evaluation Report. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USACE. 2006a. Central and Southern Florida Project Comprehensive Everglades Restoration Plan Site 1 Impoundment Project Final Integrated Project Implementation Report and Environmental Assessment. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USACE. 2006b. Final Supplemental Environmental Impact Statement: Interim Operational Plan for the Protection of the Cape Sable Seaside Sparrow. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USACE and SFWMD. 2006c. Central and Southern Florida Project Everglades Agricultural Area Storage Reservoirs: Revised Draft Integrated Project Implementation Report Environmental Impact Statement. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida, South Florida Water Management District. West Palm Beach, Florida.

USACE. 2007. Lake Okeechobee Regulation Schedule, Final Supplemental Environmental Impact Statement, November 2007. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USACE. 2009. Final Environmental Impact Statement to Construct Stormwater Treatment Areas on Compartments B and C of the Everglades Agricultural Area, Florida. January 2009. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USACE. 2010. Central and Southern Florida Project: Comprehensive Everglades Restoration Plan Caloosahatchee River (C-43) West Basin Storage Reservoir Project Final Integrated Project Implementation Report and Final Environmental Impact Statement. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USACE. 2011. Central and Southern Florida Project: Comprehensive Everglades Restoration Plan C-111 Spreader Canal Western Project Final Project Implementation Report and Environmental Impact Statement. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USACE. 2012a. Central and Southern Florida Project: Water Control Plan for Water Conservation Areas, Everglades National Park, and ENP-South Dade Conveyance System. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USACE. 2012b. Central and Southern Florida Project: Comprehensive Everglades Restoration Plan Biscayne Bay Coastal Wetlands Phase 1 Final integrated Project Implementation Report and Environmental Impact Statement. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USACE. 2012c. Central and Southern Florida Project: Broward County Water Preserve Areas Final Integrated Project Implementation Report and Environmental Impact Statement. U.S. Army Corps of Engineers, Jacksonville District. Jacksonville, Florida.

USFWS. 1999. South Florida Multi-Species Recovery Plan. Southeast Region. United States Fish and Wildlife Service. Atlanta, Georgia.

USEPA. 2010. Guidance for Implementing the January 2001 Methylmercury Water Quality Criterion, Office of Science and Technology.

Wilzbach, M.A., K.W. Cummins, L.M. Rojas, P.J. Rudershausen and J. Locascio. 2000. Establishing baseline seagrass parameters in a small estuarine bay. Pages 125-135 *in* Seagrasses: Monitoring, Ecology, Physiology, and Management, S.A. Bortone (ed). CRC Press, Boca Raton, Florida.

Wetzel, P.R., A.G. van der Valk, S. Newman, C.A. Coronado, T.G. Troxler-Gann, D.L. Childers, W.H. Orem, F.H. Sklar. 2009. Heterogeneity of phosphorous distribution in a patterned landscape, the Florida Everglades. Plant Ecology 200:69-82.

Wetzel, P.R., F.H. Sklar, C.A. Coronado, T.G. Troxler, S.L. Krupa, P.L. Sullivan, S. Ewe and S. Newman. 2011. Biogeochemical processes on tree islands in the Greater Everglades: Initiating a new paradigm. Critical Reviews in Environment and Technology 41:670-701.

Woods, J.M., and G.W. Tanner. 1990. Graminoid community composition and structure within four everglades management areas. Wetlands 10(2):127-149.

Wunderlin, R.P., and B.F. Hansen. 2008. Atlas of Florida Vascular Plants (Http://www.plantatlas.usf.edu/), [S.M. Landry and K.N. Campbell (application development,) Florida Center for Community Design and Research.] Institute for Systematic Botany, University of South Florida, Tampa.

Zweig, C.L. and W.M. Kitchens. 2008. Effects of landscape gradients on wetland vegetation communities: information for large-scale restoration. Wetlands 28(4): 1086-1096.

APPENDIX C.2.1

EFFECTS OF THE ALTERNATIVES

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C.2 EFFECTS OF THE ALTERNATIVES

C.2.1 EFFECTS OF THE FINAL ARRAY OF ALTERNATIVES

This appendix provides a detailed discussion of the potential environmental effects, which can be either positive or negative, that could result from implementation of the Central Everglades Planning Project (CEPP) Alternatives. The evaluation of the effects was based on results of modeling simulations, current information including scientific literature, direct observation, project design reports, reasonable scientific judgment, the scoping process, and other environmental impact statement (EIS) documents for similar projects. The No Action Alternative (for consistency of the report the **No Action Alternative** is referred to as the **Future Without [FWO]** for the remainder of the report), previously discussed in Section C.1.2, considers the environmental conditions in the affected regions without the Proposed Action.

Environmental impacts include both direct and indirect effects. Under the Council on Environmental Quality (CEQ) regulations, direct effects are "caused by the action and occur at the same time and place," while indirect effects are "caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 CFR 1508.8).
Under the National Environmental Policy Act (NEPA), one purpose is to identify at an early stage the significant environmental issues deserving of study and deemphasizing insignificant issues, narrowing the scope of the environmental impact statement accordingly (40 CFR Sec 1501.1). I

The resource conditions that were evaluated include climate, geology, soils, vegetation, wildlife, hydrology, water quality, flood control, air quality, hazardous, toxic and radioactive waste (HTRW), noise, aesthetics, land use, agriculture, socioeconomics, recreation, cultural resources and invasive species.

C.2.1.1 Climate

Climate change is expected to alter rainfall and evapotranspiration patterns over the next 100 years. USACE sea level change projections for the period from 2015 to 2065 for Key West, Florida and the broader south Florida area for historic, intermediate and high rates of future sea level rise are +4 inches, +10 inches and +26 inches, respectively http://publications.usace.army.mil/publications/eng-circulars/EC_1165-2-212.pdf. The regional hydrologic models used to simulate with- and without project conditions require climatic and tidal data as boundary conditions. The model tidal boundary used in the regional hydrologic model was developed using historic tidal data from two primary (Naples and Virginia Key) and five secondary NOAA stations (Flamingo, Everglades, Palm Beach, Delray Beach, and Hollywood Beach). Simulation model tidal boundary conditions that reflect future sea level change were not available for the range of potential sea level change expected. However, the impact of sea level change on project benefits is assessed in **Annex I** for the FWO and with project conditions per USACE guidance EC 1165-2-212.

Since 1900, there have been two cool phases and two warm phases of the Atlantic Multidecadal Oscillation (AMO) cycle with each of these phases lasting approximately 20-40 years each. The exact year of the phase start and finish is an estimate as each phase goes through a "transition period" of a few years. South Florida was in a much drier regime from 1965 to the early 1990s when the AMO transitioned from the cool phase to the warm phase. South Florida experienced more droughts and dry weather during the cool phase, with high-water events (some extreme) being more frequent during the current warm phase. South Florida has been in a "wetter" regime since the early 1990s mostly due to the AMO. With

AMO phases lasting typically 20-40 years, the current AMO warm phase has likely peaked. Thus, the generally wetter than normal conditions that Florida has experienced since the early 1990s should begin to slowly decline. After the peak, the warm phase wave will begin its gradual decline where we will see continually cooler anomalies over the next 10-20 years. As we approach the end of the cycle, Florida will experience an increase in dry years compared to wet years. Given the temporal stage of the current phase, conditions will continue to remain wetter than average for the next 10-20 years, but with a slow and gradual decline in intensity until this phase ends and a cool phase begins. However, low frequency dry years can still occur due to other events such as La Niña, which can occur on an average of every 2-7 years.

Global climate change and variability, particularly at regional levels, are not completely understood. Over the last two decades, South Florida Water Management District (SFWMD) scientists have researched how natural, global climatic patterns such as the El Niño/La Niña-Southern Oscillation and the Atlantic Multidecadal Oscillation are linked to South Florida's weather and climate. Based on this expanded experience and knowledge, the SFWMD has already adopted progressive measures to incorporate climate outlook into its planning and operations. The CEPP features will be designed robustly to handle extreme wet and dry conditions, floods and droughts, and will be operated based on the climate outlook described above. Climate change is difficult/controversial to predict and our CEPP assessment is not an exercise to predict what the climate change will be, but to select the best plan possible whatever climate change will occur.

Implementation of any of the CEPP action alternatives would have a negligible effect on climate within the action area. Minor, localized and less than significant effects to microclimate may occur under all CEPP action alternatives as a result of redistribution of water and shifts in vegetation. Potential effects may include increases in evapotranspiration and temperature changes due to an increase in spatial extent of wetlands, changes in vegetative communities, and redistribution of water as described in **Appendix C.1.1.1** and **Appendix C.1.3.1.**

C.2.1.2 Geology and Soils

On the A-2 flow equalization basin (FEB) footprint, with all the action alternatives, there would be minor and less than significant geologic impacts within the project area from the removal of surface cover (e.g. vegetation and soil), of caprock from blasting, and removal of limestone to obtain material for construction of levees, canals and roads. All action alternatives would result in conversion of relatively flat, uniform agricultural lands to an FEB (4 feet maximum operating depth) and exterior levees up to 10 feet above existing grade (generally 7 to 9 feet North Atlantic Vertical Datum 1988).

Improved hydroperiods and sheetflow in Water Conservation Area (WCA) 3A, WCA 3B, and Everglades National Park (ENP) reduce soil oxidation, which is expected to promote peat accretion necessary to rebuild the complex mosaic of habitats across the landscape. All action alternatives show an increase in inundation duration over the FWO that will significantly decrease soil oxidation, subsidence and peat fires. All action alternatives improved hydrologic conditions in northern WCA 3A in comparison to FWO by increasing stages and resulting hydroperiods within the area. All action alternatives scored the highest in terms of meeting the desired targets for measures of inundation duration, drought intensity, and slough vegetation suitability (**Appendix G**, **Table G-6**, **Table G-7**, and **Table G-8**). All action alternatives improved hydrologic conditions in northern and southern ENP (Zones ENP-N and ENP-S) in comparison to the FWO by significantly increasing depths and resulting hydroperiods in Northeast Shark River Slough (NESRS; **Table G-14,** and **Table G-15**). Consistent with other regions of the Greater Everglades, action alternatives scored the highest in terms of meeting the desired targets for measures

of inundation duration, drought intensity, and slough vegetation suitability. Within southern ENP, Alternatives (Alts) 3 and 4 produced slightly higher depths as depicted by the normalized weekly stage duration curve for Indicator Region (IR) 130 (**Figure G-23**). Alternative 4 produced slightly higher depths than Alternative (Alt) 3. Alternative 4 generally produced improved inundation patterns in southern ENP. Indicator region 130 was inundated for 96% of the POR for Alt 4; a 9% increase in inundation duration relative to the FWO. Alternative 3 inundated this location for 95% of the POR. Alternatives 1-2 inundated this location for 93% of the POR. Alternative 4 reduced drought intensity at IR 130 over the period of record by 676 ft-days relative to the FWO. Alternatives 3, 2, and 1 provided a reduction of 558, 477, and 456 ft-days over the POR at this location respectively. Alternative 4 improved the number and duration of dry events in NESRS relative to the remaining alternatives at several of the IRs in Zone ENP-S (**Table G-17**). Improved inundation patterns in southern ENP resulted in better suitability for slough vegetation for Alt 4 (**Figure G-24**).

C.2.1.3 Vegetation

C.2.1.3.1 Lake Okeechobee

Negligible and less than significant effects to vegetation within Lake Okeechobee's extensive littoral zone are anticipated as a result of any of the alternatives. As compared with FWO, all CEPP action alternatives reveal the potential for short-term minor adverse effects to aquatic vegetation due to higher than preferred lake stages. However, these multiple day events in which Lake Okeechobee stage exceeded 15.0 feet NGVD occurred approximately 5% of the POR. CEPP maintains stage ranges described within the Lake Okeechobee Regulation Schedule (2008 LORS); therefore effects to vegetation under the action alternatives would be as described in 2008 LORS.

C.2.1.3.2 Northern Estuaries

Currently, many submerged aquatic vegetation (SAV) beds are stressed and have been reduced or eliminated from their former areas by extreme salinity fluctuations, increased turbidity, sedimentation, dredging, damage from boats, and nutrient enrichment which causes algal blooms that, in turn, restrict light penetration. All CEPP alternatives are designed to divert water that in FWO would be released to the Atlantic Ocean and Gulf of Mexico to the A-2 FEB and Greater Everglades, therefore as compared with FWO, all CEPP action alternatives show a slight performance improvement within the Northern Estuaries as indicated by fewer high volume flow months, providing a minor beneficial effect. Reduction in high flows and accompanying flow velocities would result in lower suspended solid loading and decreased concentration of colored dissolved organic matter, thereby allowing greater light penetration to promote growth of SAV. In addition, reduction in high volume discharge events from Lake Okeechobee would reduce extreme salinity fluctuations associated with such events. Although some SAV are tolerant of a wide range of salinity levels, a reduction in high volume discharge events would reduce stress to SAV and aid in long term health of estuarine habitat and biota. Implementation of any CEPP alternative would help to maintain the target frequency and duration of water releases to the Northern Estuaries and would help curtail continued habitat loss and allow the recovery of more desirable vegetative communities.

C.2.1.3.2.1 Upper Caloosahatchee River Estuary

Negligible and less than significant effects are predicted within the Upper Caloosahatchee Estuary as a result of any CEPP action alternative.

C.2.1.3.2.2 Lower Caloosahatchee River Estuary

In the Lower Caloosahatchee Estuary, all CEPP action alternatives performed better than the FWO having fewer days at <16 practical salinity units (psu), reflecting fewer high flow events, providing minor beneficial effects. Increases of 7.8% were predicted for seagrass shoots (shoal grass) per acre at Shell Point for all of the CEPP action alternatives.

C.2.1.3.2.3 St. Lucie Estuary

Compared to FWO, all CEPP action alternatives had a higher number of days in the preferred 12 – 20 psu envelope and fewer days at <12 psu which would benefit seagrass habitat within the estuary and Indian River Lagoon providing minor beneficial effects. In comparison with FWO, an approximate 6.5% increase in manatee grass (*Syringodium filiforme*) shoots per acre is anticipated with implementation of any CEPP action alternative. Increases in low flow violations during the dry season were indicated by the modeling effort; however, due to the infrequency of the increases in these events is expected to have a negligible effect on SAV within the St. Lucie Estuary. Although these extreme dry spells are rare in the SLE, they can occur and therefore supplemental flows during dry times may be warranted and have been accounted for in the IRLS water reservation process. Delivery of those supplemental flows should ideally take place through the North Fork St. Lucie River.

C.2.1.3.3 Everglades Agricultural Area

Negligible and less than significant effects to vegetation within the Everglades Agricultural Area (EAA) are anticipated as a result of any of the action alternatives. As all of the property that will be used to construct the A-2 Flow Equalization Basin (FEB) is considered to be atypical jurisdictional wetlands based on hydric soils and hydrology; wetland vegetation is anticipated to return to the site once construction of the A-2 FEB is complete. During construction, temporary short-term effects are expected to vegetation within the construction area, however, these are considered to be minor as the land was formerly used for agriculture.

C.2.1.3.4 Greater Everglades

Due to changes in the quantity, quality, distribution and timing of water entering the Greater Everglades ecosystem, significant and moderate effects on wetland hydrology and vegetation would potentially occur under each of the CEPP action alternatives. The primary factors influencing the distribution of dominant freshwater wetland plant species of the Everglades are soil type, soil depth, and hydrological regime (USFWS 1999). All four action alternatives improved hydroperiods and sheetflow in WCA 2A, WCA 3A, WCA 3B, and ENP which result in reduced soil oxidation and promoting of peat accretion necessary to rebuild the complex mosaic of habitats across the landscape. All four action alternative provide moderate beneficial effects in hydroperiods in WCA 2A compared to FWO. However, all action alternatives had a moderate adverse effect in WCA 2B by significantly decreasing stages compared to FWO. In the L-28 Triangle, all action alternatives showed an improvement in hydroperiod over FWO, with Alt 1 having greater improvement than Alts 2-4. In the Greater Everglades, improved hydroperiods and sheetflow in WCA 3A, WCA 3B and ENP under all CEPP action alternatives result in reduced soil oxidation, which is expected to promote peat accretion necessary to rebuild the complex mosaic of habitats across the landscape. Differences among alternatives were found within northern WCA 3A, WCA 3B and southern ENP and are described in greater detail below. These differences may be largely attributed to the location of project features and distribution of water across the landscape. For example, Alt 1 which includes a 3 mile spreader canal west of S-8 provides the greatest improvements in northwestern WCA 3A. In comparison, Alts 3 and 4 provide more water to Shark River Slough (SRS) and the southern marl prairies, improving conditions for tree islands and ridge and slough habitat within ENP and salinity within Florida Bay. Alternative 1 performed slightly better than Alternatives 2, 3, and 4 in northern WCA 3A.

As a result of reduced freshwater inflow and drainage by the Miami Canal, northern WCA 3A is currently dominated largely by mono-specific sawgrass stands, with large areas of shrubs and monotypic cattail and lacks the diversity of communities that exists in central and portions of southern WCA 3A. All of the CEPP action alternatives include features to distribute water through spreader canals in the L-5 across northern WCA 3A and backfill portions of the Miami Canal north of Interstate 75, thereby increasing hydroperiods and depths within this area providing major beneficial effects. Variation in the distribution of inflows into northern WCA 3A and backfill of the Miami Canal did not significantly influence performance among action alternatives. Implementation of CEPP is expected to rehydrate much of northern WCA 3A by providing a means for redistributing treated Stormwater Treatment Area (STA) discharges from the L-4 and L-5 in a manner that promotes sheetflow and by removing the drainage effects associated with the Miami Canal. Resumption of sheetflow and related patterns of hydroperiod and water depth will significantly help to restore and sustain the microtopography, directionality, and spatial extent of ridges and sloughs and improve the health of tree islands in the ridge and slough landscape.

Alternative 1 generally produced improved inundation patterns in northwestern WCA 3A. Indicator region 114 was inundated for 92% of the POR for Alt 1; an 18% increase in inundation duration relative to the FWO. Alternatives 2, 3, 4 showed similar results; inundating this location for 91% of the POR; representing a 17% increase in inundation duration relative to the FWO. Alternative 1 generally produced higher depths within northwestern WCA 3A as depicted by the normalized weekly stage duration curve for IR 114 (**Appendix G, Figure G-12**). Although none of the action alternatives would provide the necessary inundation pattern for slough vegetation restoration, all of the CEPP action alternatives act to rehydrate northern WCA 3A thereby are expected to promote peat accretion, reducing the potential for high intensity fires and promoting transition from upland to wetland vegetation.

Rehydration of previously dry areas within northern WCA 3A has the potential to temporarily mobilize nutrients within the water column; however, this is not expected to be a significant issue since portions of WCA 3A north of Interstate 75 experience annual dryout and rehydration with no significant downstream impact. One notable concern would be the introduction of phosphorus into previously unimpacted areas (i.e. central and southern WCA 3A) potentially resulting in vegetation shifts. Chaing et al. (2000) suggested that phosphorus loadings alter the Everglades plant communities through increased plant productivity, tissue phosphorus storage, soil phosphorus enrichment and shifts in plant species composition. The overall change in phosphorus loads in most areas is expected to be minor and vegetation shifts driven by water quality should be localized. Previous studies have shown that slough and sawgrass communities have been replaced by cattail-dominated communities (Davis et al. 1994; Rutchey and Vilchek 1994, Newman et al. 1998). However, Craft et al. (1995) and Chaing et al. (2000) observed no significant change in macrophyte species diversity or expansion of cattails in study plots receiving nutrient additions during the two years and four years, respectively, of their studies. Vegetation that can assimilate nutrients directly from the water column appears to be the most sensitive to nutrient enrichment and include periphyton and floating-leaved plants, such as spatterdock and water lily (Chaing et al. 2000, Newman et al. 2004). The periphyton-*Utricularia* complex may be quite sensitive to increased phosphorus, as illustrated by the disappearance of this complex from enriched study plots after the third year (Chaing et al. 2000).

Many areas of WCA 3A, particularly within central WCA 3A still contain good quality wetland habitat consisting of a complex of tree islands, sawgrass marshes, wet prairies, and aquatic sloughs. Vegetation and landscape patterning in the central portion of WCA 3A resembles pre-drainage conditions most closely and represents some of the best examples of remnant Everglades habitat in south Florida (RE-

COVER 2009). These areas remain largely unaffected by any of the CEPP Action Alternatives. Increases in depth within central WCA 3A were not as significant as increases in observed depths in northern WCA 3A; however maintenance of existing conditions within this region of the project area is desirable as ridge and slough habitat is well conserved.

In southern WCA 3A, high water levels during the wet season are important in maintaining quality wet prairie and emergent slough habitat (USFWS 2010). However, prolonged high water levels and extended hydroperiods have resulted in vegetation shifts within southern WCA 3A, negatively impacting tree islands and fragmenting sawgrass ridges, resulting in the loss of historic landscape patterning. None of the CEPP action alternatives, as stated in the FWO discussion, would provide beneficial effects to southern WCA 3A through reduction in high water levels or duration. Alternatives 2, 3, and 4 performed slightly better than Alt 1 within southern WCA 3A. Negligible effects in vegetation are anticipated within this region.

Typical Everglades vegetation, including tree islands, wet prairies, sawgrass marshes, and aquatic sloughs also occur throughout WCA 3B. However, within WCA 3B, the ridge and slough landscape has been severely degraded by the virtual elimination of overland sheetflow due to the L-67 Canal and Levee system. WCA 3B experiences very little overland flow and has become primarily a rain-fed system predominated by shorter hydroperiod sawgrass marshes with relatively few sloughs or tree islands remaining. Water levels in WCA 3B are also too low and do not vary seasonally, contributing to poor ridge and slough patterning. Loss of sheetflow to WCA 3B has also accelerated soil loss reducing elevations of the remaining tree islands in WCA 3B and making them vulnerable to high water stages.

Alternative performance varied greatly within WCA 3B due to structural and operational variations among CEPP action alternatives with respect to construction of conveyance features within L-67 A, C and L-29 levees, along with associated levee removal. Alternative 2 scored the highest in terms of meeting the desired performance measure targets within this area, followed by Alternatives 1, 3 and 4 respectively. All action alternatives improved hydrologic conditions in WCA 3B in comparison to FWO by increasing stages and resulting hydroperiods within the area as measured by the RECOVER Slough Vegetation Performance Measure providing minor beneficial effects (See **Appendix G - Figure G-19**). Increases in stages and hydroperiods would promote wetland vegetation transition, through contraction of sawgrass marshes and expansion of wet prairies, and in deeper regions, sloughs. Plant species diversity will likely increase in WCA 3B with species composition in wet prairies determined largely by peat depth and substrate type (Powers 2005). Submerged aquatic plants are commonly associated with sloughs providing structure for growth of periphyton, the main source of primary production within the freshwater Everglades (Gunderson 1994, Powers 2005).

Although none of the action alternatives met the desired dry and wet season water depths for slough vegetation in WCA 3B, Alt 2 improved inundation patterns within WCA 3B and slightly improved conditions for slough vegetation relative to Alts 3, 1, and 4 by increasing water depths in both the wet and dry season (refer to **Appendix G**, **Figure G-18** and **Figure G-19)**. The increased ability of Alt 2 to rehydrate WCA 3B and increase hydroperiods, especially relative to Alt 4, may come at a potential cost to tree islands. The potential moderate adverse effects are greatest for Alt 2 and Alt 3 because a third of the population of tree islands in WCA 3B are only 0.7-1.1 feet above the surrounding sloughs. It is hypothesized from modeling of tree islands in WCA 2A, where 90% of tree islands have been converted to sawgrass, that tree islands cannot withstand full inundation in excess of 120 days for two years in a row (Sklar and van der Valk 2002). However, it is not clear if this is appropriate for tree islands within WCA 3B because tree island species in WCA 3B appear to be phenotypically plastic, which means they

have a greater ability to adapt to longer hydroperiods (Fred Sklar, personal communication). Increasing the operational flexibility for each alternative will allow for better adaptive management and preservation of tree islands within WCA 3B.

All CEPP action alternatives include conveyance features and levee removal within L-67A and C, thereby providing new point source discharges of water into WCA 3B. At the end of the dry season, there is the potential for flushing of water and remobilization of nutrients within the water column, potentially having a minor adverse effect on vegetation within WCA 3B. As indicated for northern WCA 3A, mobilization and introduction of phosphorus are a notable concern. However, it is anticipated that Broward County Water Preserve Areas (BCWPA) Project would be constructed prior to CEPP implementation, thereby reducing discharges from S-9 into L-67A. Currently, total phosphorous (TP) within L-67A ranges between 10 and 20 ppb, depending upon the time of year. With completion of the BCWPA Project, it is anticipated that TP within L-67A will be greatly reduced and therefore minimal effects to vegetation due to changes in water quality are anticipated within WCA 3B. Cattail expansion will be monitored as outlined within Annex D, Project Monitoring and Adaptive Management Plan. Tree islands contain extraordinarily high levels of TP in their soil suggesting that they may play a major role in the biogeochemical cycles of nutrients in the Everglades (Sah 2004, Troxler and Childers 2010, Troxler and Richards 2009, Wetzel 2002, Wetzel et al. 2009, 2011). Wetzel et al. (2011) found that soil TP levels within WCA 3A and WCA 3B tree islands were approximately 4 times higher than the surrounding marsh TP levels. Tree islands within WCA 3B may help to capture and focus nutrients, assisting to minimize potential effects on sawgrass and wet prairie communities within this region (Wetzel et al. 2011).

Flows through SRS under current system compartmentalization and water management practices are greatly reduced when compared with pre-drainage conditions. The result has been lower wet season depths and more frequent and severe dry downs in sloughs and reduction in extent of shallow water edges. Over-drainage in the peripheral wetlands along the eastern flank of NESRS has resulted in shifts in community composition, invasion by exotic woody species and increased susceptibility to fire. Implementation of CEPP is expected to rehydrate much of NESRS by providing a means for redistributing flows from WCA 3B to ENP and provide a moderate beneficial effect. Resumption of sheetflow and related patterns of hydroperiod will significantly help to restore pre-drainage patterns of water depths and the complex mosaic of Everglades' vegetation communities.

As compared with FWO, all CEPP action alternatives produced significantly higher depths and inundation durations (refer to **Appendix G**, **Figure G-21** and **Figure G-22**). Within northern ENP, alternative performance was similar with all action alternatives reducing the number of dry events within SRS and extending average hydroperiods by 35 to 90 days depending upon location. Reduction in number and duration of dry events and extended hydroperiods is expected to reduce soil oxidation, decrease fire potential, promote peat accretion and aid in restoration of historic wetland vegetation communities providing a minor beneficial effect. Within southern ENP, Alts 3 and 4 produced slightly higher depths as compared with Alts 2, 1 and FWO (refer to **Appendix G**, **Figure G-23**). Improved inundation patterns produced by Alt 4 in southern ENP resulted in better suitability for slough vegetation. Although none of the action alternatives met the desired dry and wet season water depths for slough vegetation in southern ENP; Alt 4 slightly improved conditions for slough vegetation relative to Alts 1, 2 and 3 by increasing water depths in both the wet and dry season within this region.

All CEPP action alternatives include increasing capacity at S-333 from 1350 cubic feet per second (cfs) to 3000 cfs. With an increase in S-333 flow, there is an increased likelihood of increased TP entering NESRS. Potential changes in water quality due to implementation of the CEPP action alternatives have

the potential to have a minor adverse effect on vegetation within ENP. The Everglades, a phosphorus-limited system, historically received most inputs of phosphorus through rainfall, with average TP concentrations of less than 0.01 milligrams per liter (mg/L) (McCormick et al. 1996, Newman et al. 2004). However, more recently, areas within ENP, including NESRS, have been exposed to TP concentrations at or in excess of 0.10 mg/L (SFWMD 2010). These concentrations and any additional inputs resulting from implementation of any of the CEPP action alternatives (refer to **Section 5.1.9, Water Quality** for details), have the potential to result in vegetation changes within NESRS. Vegetation that can assimilate nutrients directly from the water column appears to be the most sensitive to nutrient enrichment and include periphyton and floating-leaved plants, such as spatterdock and water lily (Chaing et al. 2000; Newman et al. 2004). Chaing et al. 2000 demonstrated that the periphyton-*Utricularia* complex may be quite sensitive to increased phosphorus, as illustrated by the disappearance of this complex from enriched study plots after the third year. Potential effects to vegetation and species community composition within NESRS and ENP cannot fully be determined at this time. Water quality within the CEPP action area will continue to be monitored, as described in **Annex D**, to determine any associated changes.

Non-native and invasive plant infestations in the action area may be exacerbated by soil disturbance, increased nutrients and hydrological modification. Many non-native and invasive species are flourishing in a variety of habitats and are negatively affecting the ecology throughout the Everglades. Non-native and invasive plant species are most frequently encountered in disturbed areas and areas where water quality has been impacted by increased nutrient loads. Construction and hydrological modification under each of the action alternatives may have a minor adverse effect on the growth of non-native plant species within the CEPP action area. Refer to **Section 5.1.17** and **Appendix C.2.1, Section C.2.1.18** for additional information.

C.2.1.3.4.1 Slough/Open Water Marsh

Deep slough communities formerly occurred throughout the pre-drainage Ridge and Slough region of the Everglades (McVoy et al. 2011). Sloughs within the Greater Everglades have been degraded by compartmentalization resulting in reduced sheetflow, depths and inundation durations, altering vegetation community structure and resulting in expansion of wet prairie and sawgrass marsh communities. Overland sheetflow has been virtually eliminated from WCA 3B due to the L-67 Canal and Levee system, resulting in the loss of deep water sloughs and dominance of shorter hydroperiod dense sawgrass marsh. Vegetative trends within ENP have also included the conversion of slough/open-water marsh communities to shorter hydroperiod sawgrass marshes and wet prairies (Davis et al. 1994, Davis and Ogden 1997; Armentano et al. 2006; McVoy et al. 2011). All CEPP action alternatives provide significant increases in sheetflow and hydroperiod with the greatest flows in ENP achieved with Alts 4 and 3, respectively, providing major and significant beneficial effects. As a result of increased flows, depths and durations, it is expected that shorter hydroperiod sawgrass marshes will transition to wet prairie and slough/open water marsh communities. Shifts from one vegetation type to another may occur in a relatively short time frame (1 to 4 years) following hydrological alteration (Armentano et al. 2006, Zweig 2008, Zweig and Kitchens 2008, Sah et al. 2008). Although none of the CEPP action alternatives met desired dry and wet season water depths for slough vegetation within WCA 3B and southern ENP; Alt 4 slightly improved conditions for slough vegetation relative to Alts 1, 2 and 3 by increasing water depths in both the wet and dry season within these regions.

C.2.1.3.4.2 Sawgrass Marsh

As a result of increased flows, depths and inundation durations under the action alternatives, it is expected that shorter hydroperiod sawgrass marshes will transition to wet prairie, except where there is

deep water that will transition to slough. It is expected that increased flow within northern WCA 3A and WCA 3B will aid to reduce dense sawgrass stands and help to promote a mosaic of wetland vegetation types within this area providing minor beneficial effects.

C.2.1.3.4.3 Wet Marl Prairies

Areas within the eastern marl prairies along the boundary of ENP suffer from over-drainage, reduced water flow, exotic tree invasion and frequent human-induced fires (Lockwood et al. 2003; Ross et al. 2006). To alleviate the perpetually drier conditions and associated problems, increased water flows within this area are required. Alternatives 3 and 4 provide more water to SRS and the southern marl prairies as compared with Alts 1 and 2, respectively. Increased hydroperiods within the eastern marl prairies may act to alleviate some of the problems associated with drier conditions and promote a shift in species community composition to benefit native vegetation and provide a minor beneficial effect.

Hydroperiods within the eastern marl prairies in the vicinity of Cape Sable Seaside Sparrow (CSSS), sub-population E (CSSS-E), along the eastern edge of SRS (**Figure C.2.1-18**), reveal an increase in hydroperiod with implementation of any of the CEPP action alternatives, with an average annual increase ranging from 25 days (Alt 2) to 31 days (Alt 4) within the vicinity of IR-E1 and 18 (Alt 2) to 22 days (Alt 4) within the vicinity of IR-E2 (**Figure C.2.1-34** and **Figure C.2.1-35**). Increased hydroperiods within the eastern marl prairies may potentially result in a shift in vegetation and a significant and unavoidable adverse effect. Ross et al. (2004) noted differences in species composition within wet prairies based upon hydroperiod. Shorter hydroperiod prairies were dominated by *Muhlenbergia* (muhly grass), *Schizachyrium* (little bluestem) and *Paspalum* (bahia grass), while longer hydroperiod prairies consisted of *Cladium* (sawgrass), *Schoenus (sedge) and Rhynchospora* (beak-rush).

Analyses of hydroperiods with the northwestern marl prairies in the vicinity of CSSS, subpopulation A (CSSS-A) reveal a reduction in hydroperiod in this area as compared with the FWO. Pollen data indicate that the marl prairies west of SRS are not a natural feature of the Everglades landscape but developed after twentieth century hydrologic modification of the system reduced flow to the region (Bernhardt and Willard 2006). Prior to the modifications, plant communities at the sites analyzed by Bernhardt and Willard (2006) in western SRS consisted of sawgrass marshes. The authors concluded that "the current spatial distribution and community composition of marl prairies are a response to water management and land cover changes of the twentieth century; and further sampling of modern marl prairie communities and adjacent communities is necessary to document the pre- and post-drainage distribution of marl prairie" (Bernhardt and Willard 2006). Although in the southwestern marl prairies (A-2), the marl prairie hydroperiod target is met less frequently as compared with the FWO (9 out of 41 years for FWO compared with 8 out of 41 years for all CEPP action alternatives); the difference is not likely to result in a significant vegetation transition to historic sawgrass marshes.

C.2.1.3.4.4 Tree Islands

C.2.1.3.4.4.1 Northern WCA 3A

Since it is not yet clear how to restore the "ghost" tree islands that are indicative of where tree islands existed some 60 years ago, nor restore the density and pattern of islands that existed before drainage of the Everglades in 1888, the objectives for CEPP restoration for tree islands is predominantly to do no more harm. It is also to create a hydrologic regime that will facilitate a return of the elevations, extent, and diversity that currently exists (as reference sites) in central WCA 3A and in regions of ENP, where islands appear to be relatively large, healthy and devoid of exotics. The problem is that restoration

solutions for one region of the landscape will not work for all regions because the legacy of water management is a strongly compartmentalized ecological landscape.

For this analysis of the four CEPP action alternatives it is necessary to focus on three regions where tree islands have been struggling to survive. Due to the complexity of the management options associated with CEPP in WCA 3B, this analysis is focused on: 1) northern WCA 3A, 2) southern WCA 3A, and 3) SRS within ENP.

Over the last 100 years of drainage and water management, northern WCA 3A has been significantly drier than all the other wetlands in WCA 3. This has caused the sawgrass-plains community to expand along the Eastern boundaries of WCA 3 (Davis 1943), the ridge and slough pattern to disappear (**Figure C.2.1-1**), and tree islands to be small and extremely few in numbers (**Figure C.2.1-2**). Most of the tree islands left in northern WCA 3A are small round features with no obvious natural tear-drop shape. Many have very short hydroperiods and only support terrestrial vegetation because they "sit" on high rock pedestals, which prevent them from subsiding to the same extent as the surrounding marshes.

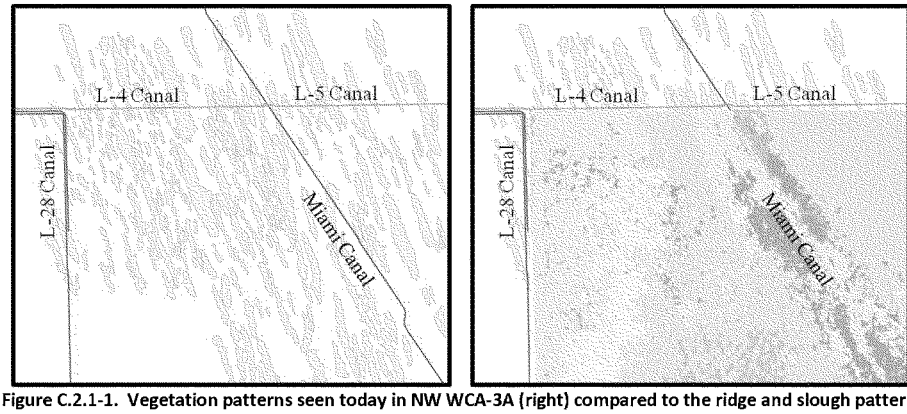


Figure C.2.1-1. Vegetation patterns seen today in NW WCA-3A (right) compared to the ridge and slough pattern observed in 1942 black & white aerial photography (left). The L-4, L-5 and L-28 canals are shown as geo-references and did not exist in 1942. Color legend for current vegetation map: Light Blue=sawgrass; Dark Blue=slough vegetation; Purple=cattail; Yellow=shrubs/sawgrass; Peach=shrubs/trees.

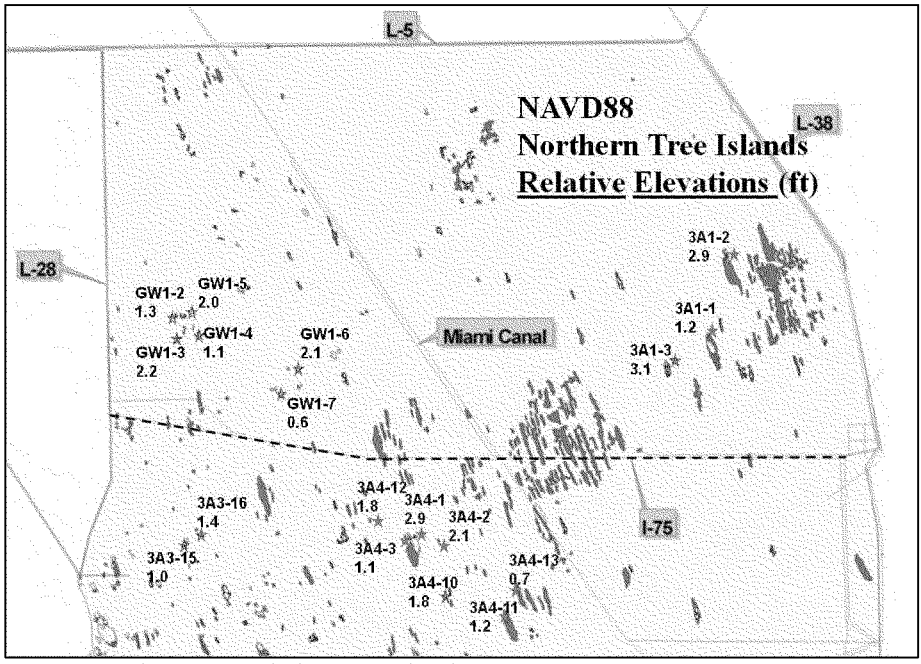


Figure C.2.1-2. Shrub-dominated ridges and tree islands in northern WCA 3A that are greater than or equal to 2 hectares are show as green (islands getting larger), yellow (islands that have not changed), or red (shrubs and trees no longer exist).

Mean annual ponding depths, comparing CEPP action alternatives and FWO within northern WCA 3A (**Figure C.2.1-3**) indicate widespread hydrological improvement and minor beneficial effect. With the exception of areas immediately downstream of the S-11 structures (separating southern WCA 2A from WCA 3A), none of the areas in northern WCA 3A under ECB and FWO conditions have an annual water depth greater than one foot. However, with the backfilling of the Miami Canal as part of the action alternatives and with all FEB waters going to the NW Spreader Canal (Alt 1) the water depths significantly increase throughout the Greater Everglades, but especially in the western areas of northern WCA 3A, where the average depth increases from 0.5 foot to 2.0 feet. This increased average water depth pattern is only slightly different than those calculated for Alts 2, 3 and 4, which all exhibited an increase in the spatial extent of the 2.0 ft average water depths along the central Miami Canal area and in northeastern WCA 3A. The increased depths are not expected to adversely affect tree islands. These water depths are not expected to create any flooding stress on islands that already exist and especially those needed by the wading birds for nesting (designated as 3A1-1, 3A1-2 and 3A1-3 in **Figure C.2.1-2**). Instead these water depths are expected to significantly increase fish habitat and density of fish and improve the potential for tree island restoration.

As indicated in **Figure C.2.1-4**, all CEPP action alternatives result in similar patterns of rehydration within northern WCA 3A and all significantly decrease the amount of time when this region goes completely

dry. Gage 3A-3 in northeastern WCA 3A, used to track droughts, indicates that with the FWO, this area will continue to be dry 40% of the time and that only 10% of the time is there more than one foot of water in the area. Tree islands are connected to the surrounding peat marshes via the roots of the trees. Although tree roots are still receiving water from wicking within the peat (unless the tree island is rocky), when the water table drops below these roots, the microclimate of these islands gets too dry and they can burn. All CEPP action alternatives create the hydrology necessary to restore tree islands and reduce the potential for devastating fires providing major beneficial effects. Under all CEPP action alternatives, the duration of water above marsh surface increases to 90%, but at the same time, tree island flooding stress (i.e., ponding depths greater than 3.0 ft) remained extremely rare.

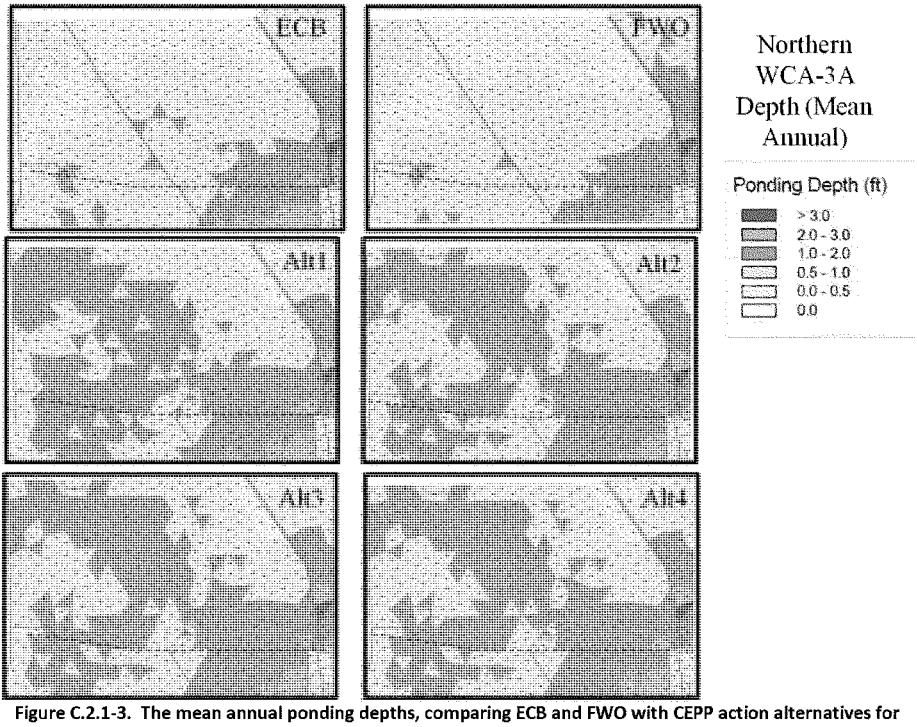


Figure C.2.1-3. The mean annual ponding depths, comparing ECB and FWO with CEPP action alternatives for northern WCA 3A.

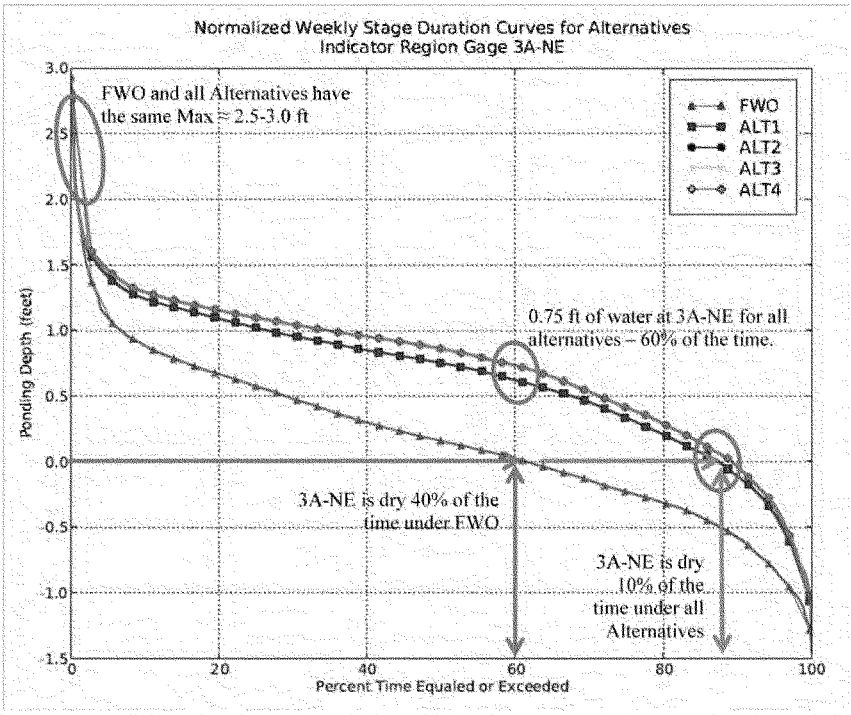


Figure C.2.1-4. All the action alternatives rehydrate this Northern Eastern WCA 3A gage location to similar amounts and all significantly decrease the amount of time when this region goes completely dry.

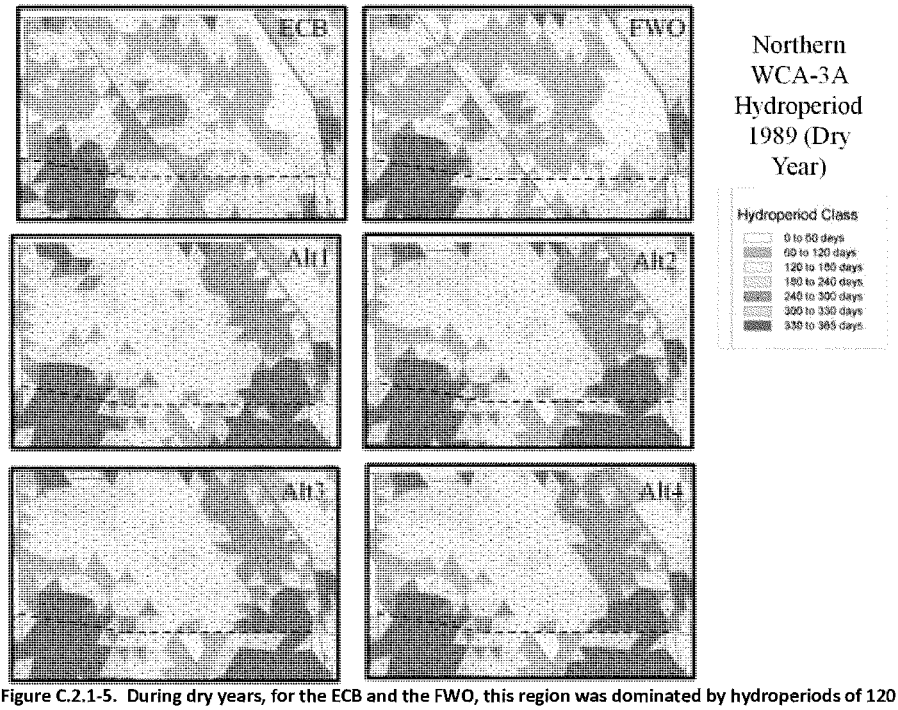


Figure C.2.1-5. During dry years, for the ECB and the FWO, this region was dominated by hydroperiods of 120 days or less. This degree of dryness makes tree islands and their associated nesting wading birds vulnerable to fires and nest predation by raccoons. All the action alternatives remove this hydrologic and predatory stress.

Rehydration of northern WCA 3A is expected to prevent further tree island degradation and peat fires, and set in motion trends to restore ridge-slough-island patterns. To consider this expectation, the hydroperiod response to a particularly dry year (1989) was evaluated (**Figure C.2.1-5**). In 1989, for ECB and FWO, this region was dominated by hydroperiods of 120 days or less. For FWO, regions downstream of S-11 became dry all year round. This degree of dryness makes the tree islands, used by large numbers of wading birds for nesting, extremely vulnerable to fires and nesting predation by raccoons. All CEPP action alternatives remove this hydrologic stress because the slope of the land in this northern region is mostly from west to east, so most of the water that enters in the west with Alts 1, 2, 3, and 4 (even during very wet years like 1995) tends to flow to regions in the east (**Figure C.2.1-6**). With all CEPP action alternatives, northern WCA 3A will no longer have extremely short hydroperiods. Instead, this area will have more spatially uniform hydroperiods that vary between 120 and 240 days providing a minor beneficial effect.

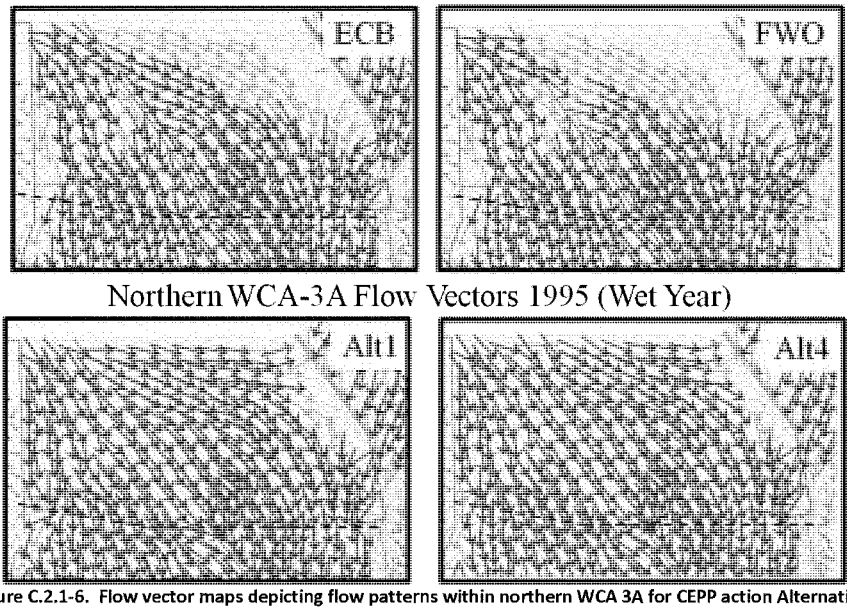


Figure C.2.1-6. Flow vector maps depicting flow patterns within northern WCA 3A for CEPP action Alternatives in comparison with ECB and FWO. Flow patterns for Alt2 and Alt3 were the same as Alt4. The ECB and FWO do a poor job of rehydrating the NE-WCA3A.

C.2.1.3.4.4.2 Southern WCA 3A

The long-term goals for CERP are to reconnect the historic flow paths along the flow lines shown in **Figure C.2.1-7**. As part of CEPP, this tree island evaluation looks at the L1 and L2 transects in relation to the known elevations of tree islands along a 2-mile swatch down each North-South transect represented in **Figure C.2.1-7**. **Figure C.2.1-7** indicates that some 60% of the tree islands in WCA 3A have been converted to marsh since 1942. It also shows the extent of currents islands throughout the landscape. Upon review of soil elevations and water depths along the L1 transect (**Figure C.2.1-8**); it is very difficult to see any differences between any of the action alternatives. The only differences were: 1) a slight reduction in water depths just north of Tamiami Trail (Highway 41) in southern WCA 3A for Alt 4; and 2) a slight increase in water depths at the very top of the L1 transect for Alt 1. Neither of these differences appears to be great enough to have any effects on tree islands. Hydrologic regimes in central WCA 3A for each alternative were not different. However, hydrologic regimes in ENP did change substantially with each alternative and potential impact to these tree islands are discussed in further detail within the SRS section. It should be noted that islands in ENP are much higher and drier than the surrounding marshes and as a result, none of the action alternatives caused any flooding stress for tree islands.

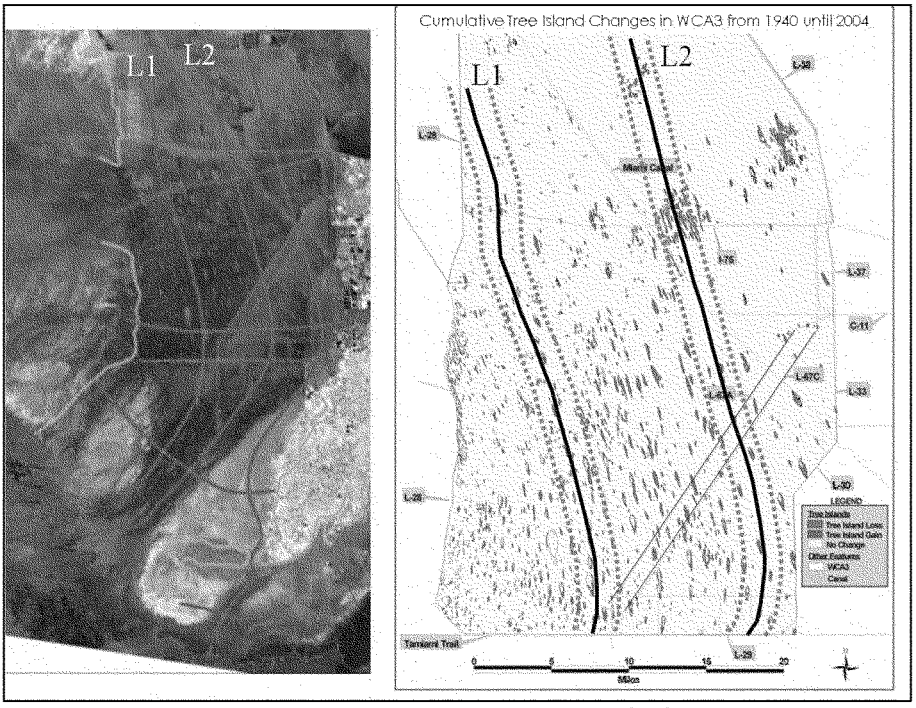


Figure C.2.1-7. L1 and L2 are historic flow paths across the extant landscape (Left) and across known elevations of tree islands within a 2-mile swatch down each N-S transect (Right).

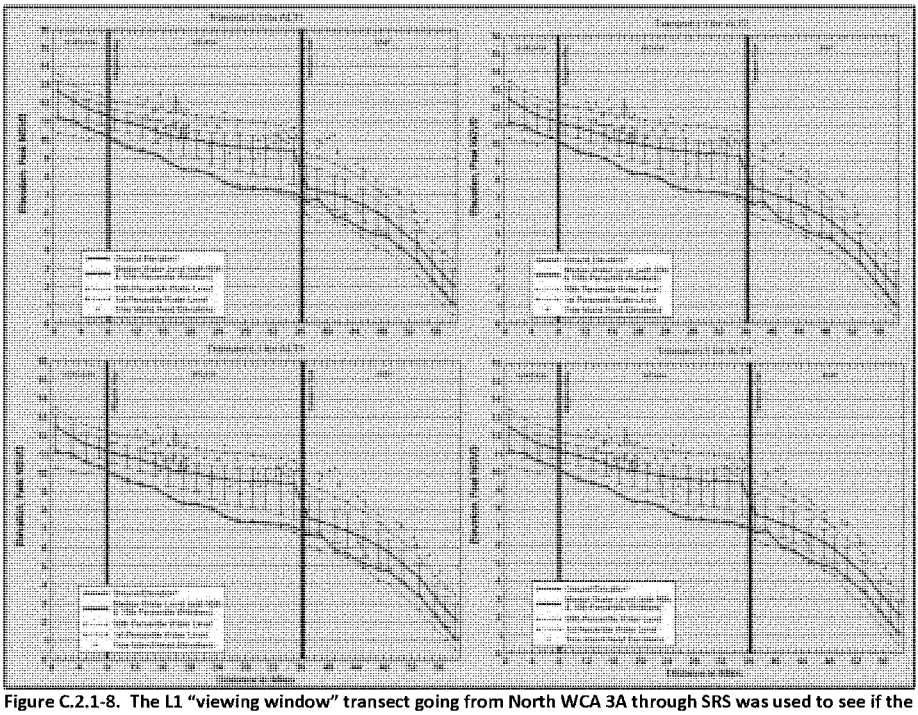


Figure C.2.1-8. The L1 "viewing window" transect going from North WCA 3A through SRS was used to see if the water depths (means and Std Deviations relative to ground elevations) for the four CEPP action alternatives were likely to increase or decrease flooding stress on tree islands (green triangles).

Changes in hydrology along the L2 transect (**Figure C.2.1-7**) in relationship to tree islands did not capture as many islands as the L1 transect, but showed the same result as Figure (**Figure C.2.1-8**) (i.e. no impacts to tree islands in WCA 3A). However, there were some small differences between Alts 1, 2 and 3 in comparison to Alt 4 in WCA 3B (**Figure C.2.1-9**). Alternative 2 (also indicative of Alt 1 and 3 results) added about 0.5 ft of depth to WCA 3B. Rehydration of WCA 3B is expected to prevent harmful fires that result in tree island loss.

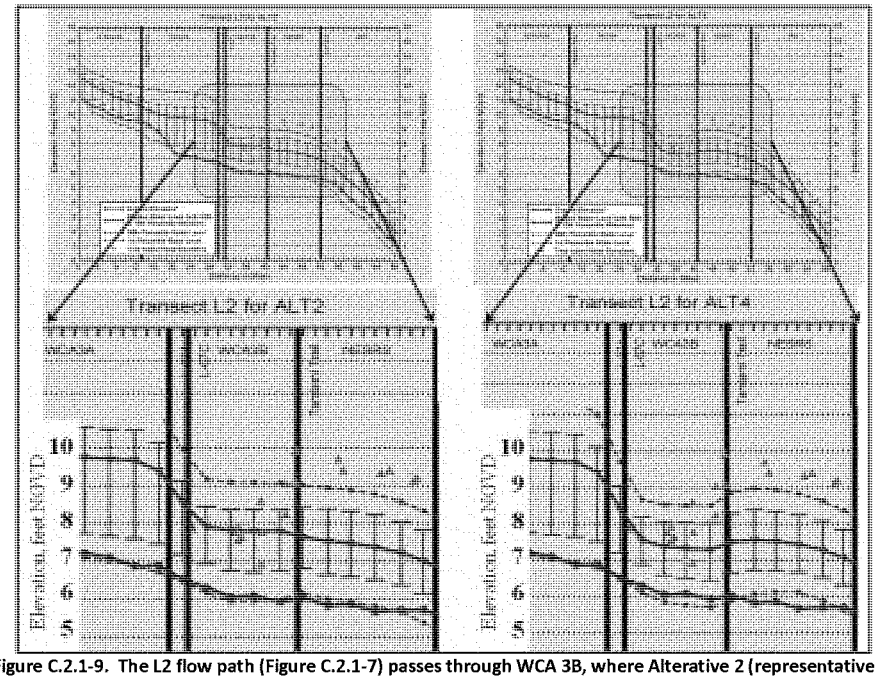


Figure C.2.1-9. The L2 flow path (Figure C.2.1-7) passes through WCA 3B, where Alterative 2 (representative of Alt-1 and Alt-3) added about 0.5 ft of additional water, which is not considered to be great enough to cause flooding stress and may instead prevent tree islands from burning.

Finally, for Southern WCA 3A, none of the action alternatives had any impact on tree islands in comparison to the FWO (**Figure C.2.1-10**). This was due to the inclusion of the 2012 Everglades Restoration Transition Plan (ERTP) WCA 3A regulation schedule in FWO. The ERTP effectively lowers the potential of flooding stress of trees on trees islands in the most southern reaches of WCA 3A. All the CEPP action alternatives provide similar benefits to tree islands within southern WCA 3A because they include ERTP.

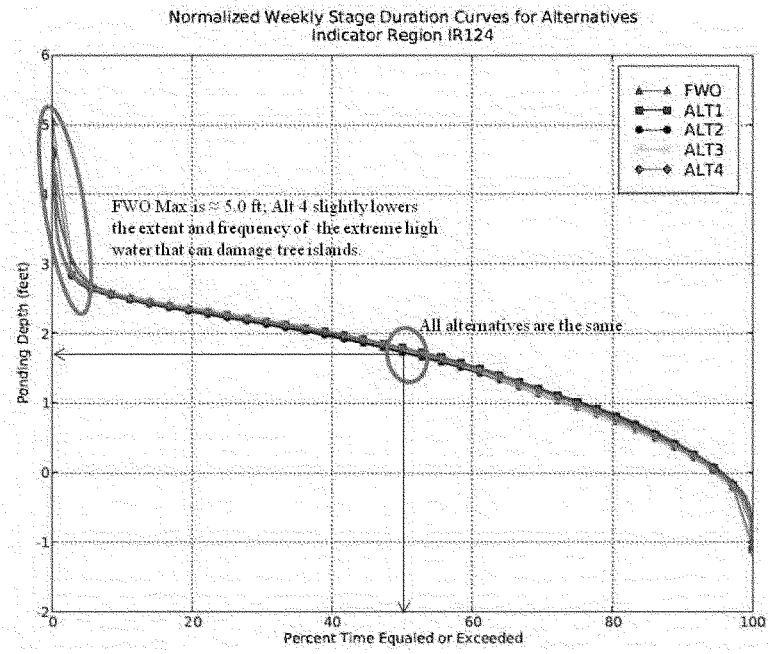


Figure C.2.1-10. Indicator Region 124 is in the southern extent of WCA 3A where tree islands can occasionally be stressed by depths greater than 2.5 ft for extended periods of time. The ERTP schedule in the FWO reduced that stress and Alt-4 was found to slightly reduce this stress even more. F or most of the time, all action alternatives were the same as the FWO.

C.2.1.3.4.4.3 Shark River Slough (SRS)

Tree islands in SRS rise high above the surrounding marsh (**Figure C.2.1-8** and **Figure C.2.1-9**). Their potential for flooding stress is practically non-existent. Instead, ENP is faced with a reduction in islands due to intensive fires that migrate across the marshes and burn tree island peat soils leaving only rocky outcroppings. The objective of CEPP action alternatives is to prevent extensive dry-downs and create extended hydroperiods. **Figure C.2.1-11** shows a 55% decline in the extent and number of tree islands in SRS since 1942 and it shows that the entire region, including the Rocky Glades along the eastern border of SRS, has a hydroperiod less than 180 days for a typical dry year under ECB and FWO conditions. The FWO expands the driest hydroperiod classification across the area during wet and dry years compared to the ECB. The Action alternatives create similar hydroperiods across the area (**Figure C.2.1-12**), and are significantly better at maintaining longer hydroperiods within SRS and of Tamiami Trail compared to the ECB and FWO. Alternative 4 appears to do the best job of creating regions with hydroperiods created than 180 days and preventing regions from completely drying out during a dry year like 1989 (**Figure C.2.1-12**).

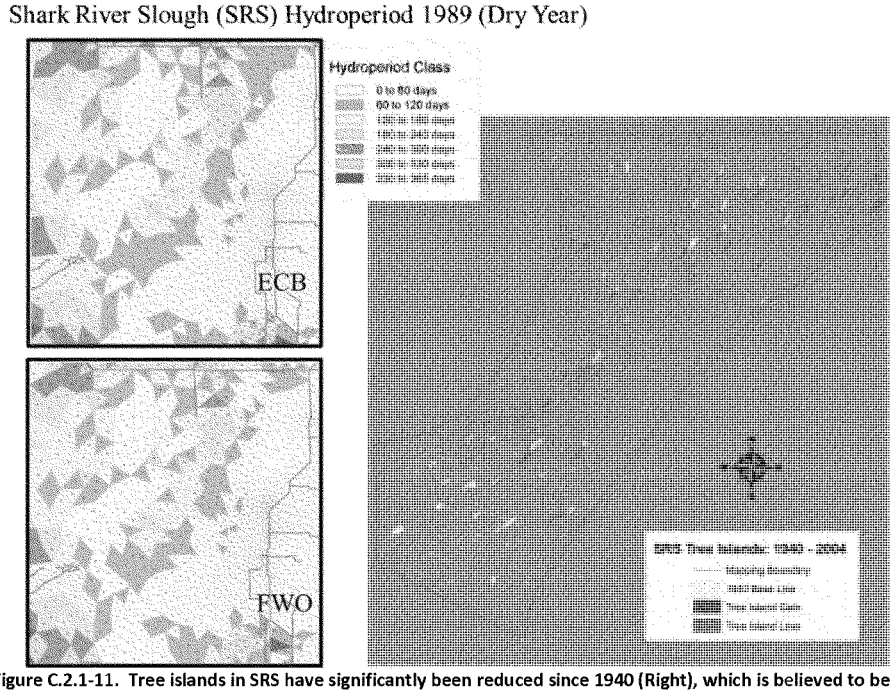


Figure C.2.1-11. Tree islands in SRS have significantly been reduced since 1940 (Right), which is believed to be caused by intense fires that occur during dry years like 1989 when hydroperiods are less than 120 days over vast areas (Left). The FWO is not an improvement over the ECB, especially immediately downstream of Tamiami Trail.

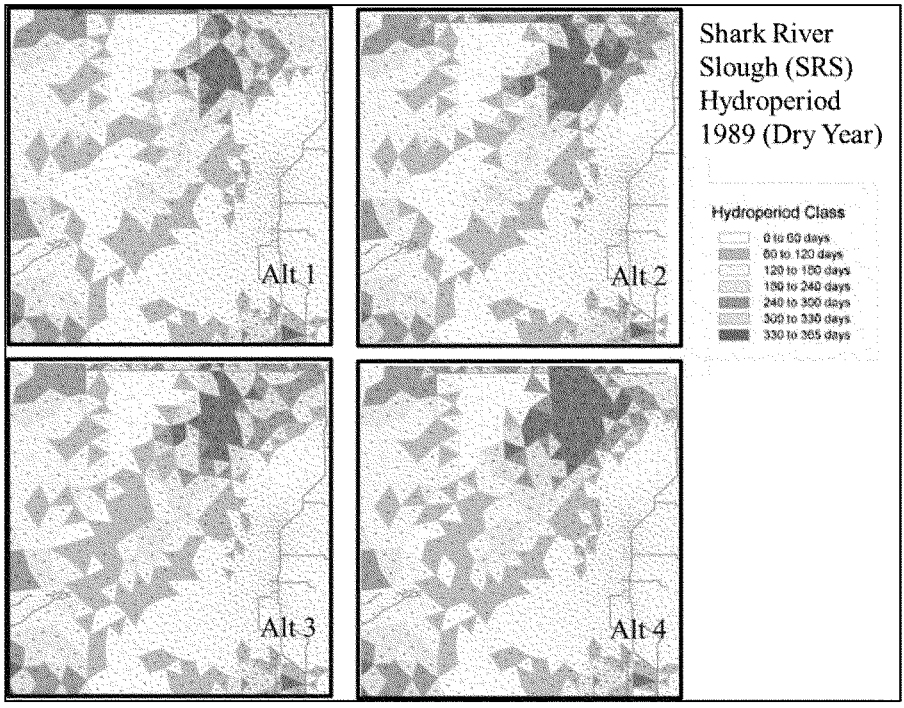


Figure C.2.1-12. Alternative 1 was the least effective at expanding the spatial extent of the 60-180-day hydroperiod classes and Alt-4 was the most effective. Alt-4 was the most effective at creating regions with hydroperiods of up to 300 days.

Figure C.2.1-13 may be the best graphic for depicting the overall hydrologic improvements in SRS, especially in the NESRS, downstream of Tamiami Trail (Gage NESRS1), associated with the CEPP action alternatives in comparison to the ECB and the FWO. This region saw significant improvements to the hydrology for tree islands because none of the action alternatives created water depths indicative of flooding stress and all the action alternatives, especially Alt 4, were able to prevent the marsh habitat surrounding tree islands from drying out for extended periods of time, thus reducing the potential for tree island degradation due to fires. Reduction of fires would be very protective of tree islands and may enhance the redevelopment of healthy tree island tails since flow fields are also expected to improve. Alternative 4 gave this region a little added protection compared to the other alternatives because it was the only alternative that prevented NESRS1 from going completely dry in 1974, a very dry year. The additional water depths of 1.0 foot associated with all the action alternatives during wet years did not increase maximum depths above 3.0 feet and as such did not represent a flooding stress to tree islands.

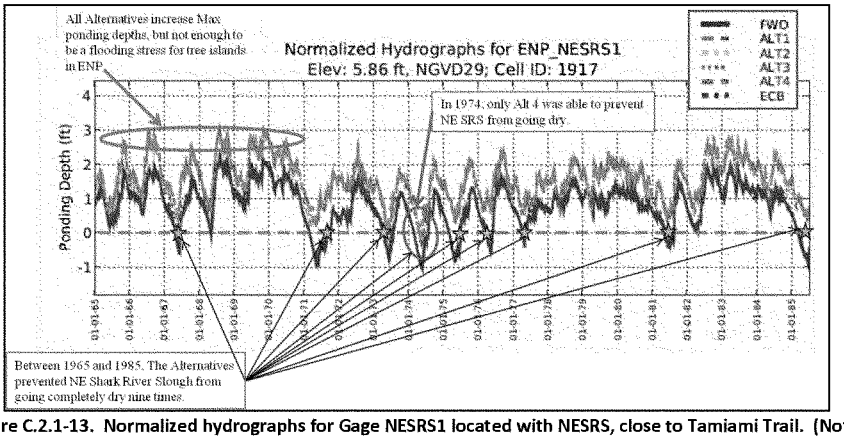


Figure C.2.1-13. Normalized hydrographs for Gage NESRS1 located with NESRS, close to Tamiami Trail. (Note: These data in Figure C.2.1-13 are shown as an example; the same trends were observed for the second half of the 41-year simulations.)

The normalized stage duration curve for central SRS Gage P-33 (**Figure C.2.1-14**) is a good summary of the hydrologic benefits of the action alternatives for tree islands in ENP. The additional 0.5 ft of water in SRS is expected to better reconnect the groundwater dynamics (roots and peat) of tree islands to the hydrology of the surrounding marshes. This has been found in tests done in the Loxahatchee Impoundment Landscape Assessment Facility to be an important natural connectivity that hydrates the island peats, transports nutrients and supports vegetative growth (Fred Sklar, Personal Communication). The action alternatives rehydrate SRS without creating any long periods of high water depths that could cause flooding stress. The FWO and all action alternatives have the same maximum water depths of approximately 3.0 ft. The advantage to tree islands of one alternative over another does not appear in the stage duration analysis until stages fall below 1.0 foot. Alternative 4 was most protective of extant tree islands and most likely to enhance tree island restoration and growth because it had the longest hydroperiod aboveground elevations and the shallowest belowground water table of any of the other alternatives.

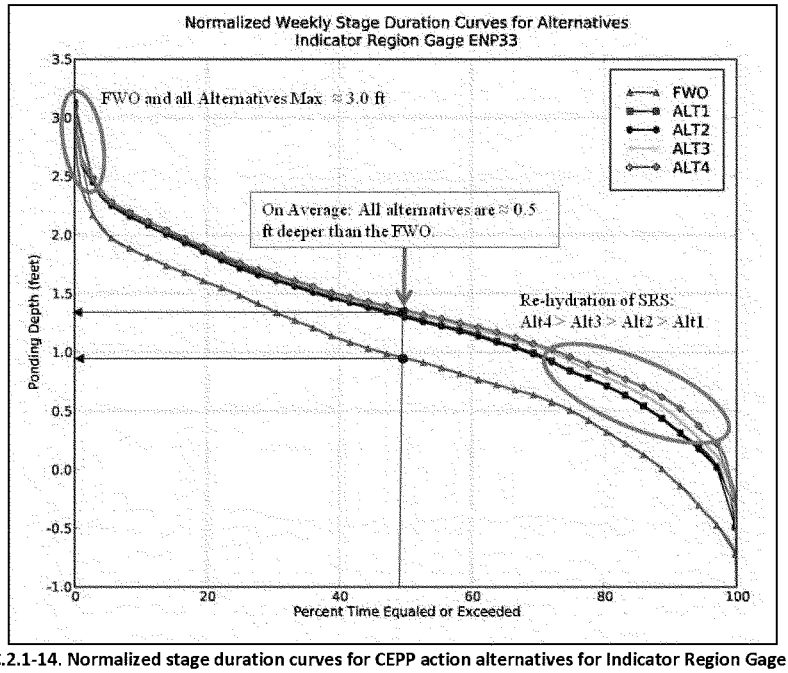


Figure C.2.1-14. Normalized stage duration curves for CEPP action alternatives for Indicator Region Gage ENP33.

In summary, negligible and less than significant effects to tree islands within WCA 3A and ENP are anticipated to occur under any of the CEPP action alternatives; however, lower elevation tree islands within WCA 3B may have a significant and major adverse effect by CEPP implementation, with Alts 2 and 3 resulting in the greatest potential impact. Approximately one-third of all tree islands within WCA 3B are elevated only 0.7-1.1 feet above the surrounding marsh. Due to increased stages within WCA 3B, these tree islands may suffer inundation and prolonged high water periods that may induce stress. It is hypothesized from modeling of tree islands in WCA 2A, where 90% of tree islands have been converted to sawgrass, that tree islands cannot withstand full inundation in excess of 120 days for more than two years in a row (Sklar and van der Valk 2002). According to Wu et al. (2002), when water depths on tree islands exceed one foot for greater than 120 days, even the most water tolerant species are affected. However, it is not clear if this is appropriate for tree islands within WCA 3B because tree island species in WCA 3B are considered phenotypically plastic, meaning they have a greater ability to adapt to longer hydroperiods (Fred Sklar, personal communication). Increasing the operational flexibility for each alternative will allow for better adaptive management and preservation of tree islands within WCA 3B.

Extended ponding of deep water, most notably within southern WCA 3A, has resulted in a lack of seedling establishment on tree islands due to stress from prolonged inundation (McKelvin et al. 1998). Lowering of water levels within southern WCA 3A would aid in reducing future tree island degradation due to prolonged inundation and high water depths. However, little change in water levels within southern WCA 3A will be realized with implementation of any of the CEPP action alternatives.

C.2.1.3.4.5 Rockland Pine Forest

No changes in hydrology are expected within rockland pine forest and therefore negligible and less than significant effects are predicted within Rockland pine forest as a result of implementation of any of the CEPP action alternatives.

C.2.1.3.4.6 Tropical Hardwood Hammock

Tropical hardwood hammocks on the Miami Rock Ridge have been affected by a lowered water table associated with the reduction of freshwater flow through the Everglades. Since all CEPP action alternatives provide increased flow through the Greater Everglades, it is anticipated that tropical hardwood hammocks would have minor beneficial effects from implementation of any of the CEPP action alternatives. As with other vegetative communities, Alts 4 and 3, respectively, would provide the greatest rehydration benefits to ENP as compared with Alts 1, 2 and FWO.

C.2.1.3.5 Southern Coastal Systems

The estuarine communities of Biscayne and Florida Bays have been affected by upstream changes in freshwater flows through the Everglades and eastward across the Miami Rock Ridge. The estuarine communities of Biscayne Bay have been further affected by agricultural and urban development of the areas east of the current boundaries of Everglades National Park.

C.2.1.3.5.1 Mangroves

A reduction in freshwater inflows into Florida Bay and alterations of the normal salinity balance have affected mangrove community composition and may have contributed to a large-scale die-off of seagrass beds (USFWS 1999). Mangrove communities along Biscayne Bay have also seen a reduction in freshwater inflows and a reduction in historic habitat range by urban and agricultural development leaving only a remnant ribbon of suitable habitat immediately adjacent to the Bay. Mangrove communities occur within a range of salinities from 0 to 40 psu. Both bays experiences salinities in excess of 40 psu on a seasonal basis. Biscayne Bay is also subject to rapid decreases in salinity on the order of 10-20 psu from fresh water pulses delivered by the surface water management canal system.

As compared with FWO, all CEPP action alternatives provide increased freshwater flows to Florida Bay and the Southwest Coast, thereby aiding to lower salinities levels within these areas to better encompass mangrove salinity tolerance range and providing a minor beneficial effect. Alternative 4 is anticipated to provide the greatest benefit, followed by Alts 3, 1 and 2 (refer to Appendix G for Florida Bay Salinity Performance Measure results).

In Biscayne Bay, Alt2 was the only alternative that provided additional flows when compared to FWO and has a minor beneficial effect. Alts 1, 3, and 4 all provided less water than FWO, in descending order having a minor adverse effect. Flows to the coast were not evenly distributed with all alternatives showing positive benefits in the northern Biscayne Bay and negative effects in central and southern Biscayne Bay. Alternative 2 is likely to provide a significant benefit to the mangrove communities by providing additional flows to the coast, thereby lowering salinity levels and/or reducing the number of days salinities exceed 40 psu. Alternative 1 is likely to provide the same level of benefit as FWO and Alts 3 and 4 would likely result in a significant negative effect to the mangrove communities by increasing the likely hood of maintaining salinity conditions in Biscayne Bay above the preferred salinity range of mangroves for longer periods of time than FWO. All alternatives generally show an unfavorable seasonal flow pattern with reductions in flows compared to FWO generally greater during the dry season. Refer to **Annex E** for Biscayne Bay Flow at Coastal Structures.

C.2.1.3.5.2 Seagrass Beds

Seagrasses within Biscayne and Florida Bays have long suffered from high salinities due to long-term reductions of freshwater flow. In addition, seagrass beds in Biscayne Bay are also subject to rapid decreases in salinity on the order of 10-20 psu and scouring of bottom sediments from fresh water pulses delivered by the surface water management canal system. Seagrasses have an optimum salinity range of 24 to 35 psu, but can tolerate considerable short-term salinity fluctuations.

As compared with FWO all action alternatives provide increased freshwater flows to Florida Bay and the southwestern coastal estuaries, thereby lowering salinities within these areas to better align with seagrass salinity tolerance ranges and providing a significant beneficial effect in coastal bays and nearshore to the transition zone. Models predicted that reduced salinity would contribute to enhanced seagrass species diversity and improved resilience of the ecosystem in northern Florida Bay.. Alternative 4 provides the greatest benefit, followed by Alts 3, 1 and 2. Refer to Appendix G for Florida Bay Salinity Performance Measure results.

In Biscayne Bay, Alt2 was the only alternative that provided additional flows when compared to FWO and has a minor beneficial effect. Alts 1, 3, and 4 all provided less water than FWO, in descending order, having a minor adverse effect. Flows to the coast were not evenly distributed spatially with all alternatives showing positive benefits in the northern Biscayne Bay and negative effects in central and southern Biscayne Bay. Alternative 2 is likely to provide a benefit to the seagrass beds by providing additional flows to the coast, thereby lowering salinity levels and/or reducing the number of days salinities exceed 40 psu. Alternative 1 is likely to provide the same level of benefit as FWO and Alts 3 and 4 would likely result in a negative effect to the seagrass beds by increasing the likely hood of maintaining salinity conditions in Biscayne Bay above the preferred salinity range of seagrasses for longer periods of time than FWO. All alternatives generally show an unfavorable seasonal flow pattern with reductions in flows compared to FWO generally greater during the dry season. Refer to **Annex E** for Biscayne Bay Flow at Coastal Structures.

C.2.1.4 Threatened and Endangered Species

The overall objective of CEPP is to rehydrate the Everglades in order to help restore the WCAs and the Everglades back to historical, pre-drainage conditions. This should improve conditions for Everglade snail kite, wood stork, and other wading birds and their habitats in south Florida, while CEPP also strived to maintain nesting season requirements for the Cape Sable Seaside Sparrow (CSSS).

Federally threatened, endangered, and candidate species that may occur within the study area include: Florida panther (*Puma concolor coryi*), Florida population of West Indian Manatee and its critical habitat (Florida manatee) (*Trichechus manatus*), Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*), Everglade snail kite (*Rostrhamus sociablis plumbeus*) and its critical habitat, Northern crested caracara (*Caracara cheriway*), piping plover (*Charadrius melodus*), red-cockaded woodpecker (*Picoides borealis*), roseate tern (*Sterna dougallii dougallii*), wood stork (*Mycteria americana*), American alligator (*Alligator mississippiensis*), Florida bonneted bat (*Eumops floridanus*), American crocodile (*Crocodylus acutus*) and its critical habitat, Eastern indigo snake (*Drymarchon corais couperi*), Schaus swallowtail butterfly (*Heraclides aristodemus ponceanus*), Miami blue butterfly (*Cyclargus thomasi bethunebakeri*), Florida leafwing butterfly (*Anaea troglodyta floridalis*), Bartram's hairstreak butterfly (*Strymon acis bartrami),* Stock Island tree snail (*Orthalicus reses* [not incl. *nesodryas*]), crenulate lead-plant (*Amarpha crenulata*), Cape Sable thoroughwort (*Chromolaena frustrata*) deltoid spurge (*Chamaesyce deltoidea*

ssp. *deltoidea*), Garber's spurge (*Chamaesyce garberii*), Okeechobee gourd (*Cucurbita okeechobeensis* ssp. *okeechobeenis*), Small's milkpea (*Galactia smallii*), tiny polygala (*Polygala smallii*), smalltooth sawfish (*Pristis pectinata*) and its critical habitat, Gulf sturgeon (*Acipenser oxyrinchus desotoi*) and its critical habitat, blue whale (*Balaenoptera musculus*), finback whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricata*), leatherback sea turtle (*Dermochelys coriacea*), Kemp's ridley sea turtle (*Lepidochelys kempii*), loggerhead sea turtle (*Caretta caretta*), Johnson's seagrass (*Halophila johnsonii*) and its critical habitat, elkhorn coral (*Acropora palmata*) and its critical habitat, and staghorn coral (*Acropora cervicornis*) and its critical habitat. Species described in the following section were determined by the Corps to potentially be affected by the project. No effect species determinations are described in Annex A, CEPP Biological Assessment and the CERP Programmatic Biological Assessment for NOAA NMFS.

The USACE and USFWS, in conjunction with the multi-agency CEPP team, used performance measures (PMs, **Table C.2.1-1**) and ecological targets (ETs, **Table C.2.1-2**) for each species and their habitat developed for the Everglades Restoration Transition Strategy (ERTP) (USFWS 2012). Performance Measures (PMs) are defined as a set of operational rules that identify optimal WCA 3A water stages and recession rates to improve conditions in WCA 3A for snail kite, wood stork, wading birds, and tree islands. The USACE believes that the depths in PM-B are too restrictive and therefore did not use that PM in our analysis of effects. Instead, we deferred to using apple snail (PM-C) PM as a more appropriate assessment since they are based upon published literature (Darby). In addition, PM-A addresses the nesting window for CSSS-A, as outlined in the 1999 USFWS Reasonable and Prudent Alternative (RPA). Ecological Targets are designed to support the intention of the PMs by providing hydroperiod guidelines to help maintain appropriate nesting and foraging habitat. As referenced in the ERTP PMs and ETs (USACE 2011), **Figure C.2.1-15** shows the locations of the gages specified within the ERTP PMs and ETs.

Table C.2.1-1. ERTP Performance Measures Used to Evaluate Potential CEPP Effects on Threatened and Endangered species.

Species	PM	Description of PM
CSSS	A	*NP-205 (CSSS-A): Provide a minimum of 60 consecutive days at NP-205 below 6.0 feet NGVD beginning no later than March 15*
Everglade Snail kite	B	WCA-3A: For Everglade snail kites, strive to reach waters levels between 9.8 and 10.3 feet NGVD by December 31, and between 8.8 and 9.3 feet between May 1 and June 1.
	C	*WCA-3A: For apple snails, strive to reach water levels between 9.7 and 10.3 feet NGVD by December 31 and between 8.7 and 9.7 feet between May 1 and June 1.*
	D	*WCA-3A (Dry Season Recession Rate): Strive to maintain a recession rate of 0.05 feet per week from January 1 to June 1 (or onset of the wet season). This equates to a stage difference of approximately 1.0 feet between January and the dry season low.*
	E	*WCA-3A (Wet Season Rate of Rise): Manage for a monthly rate of rise less than or equal to 0 .25 feet per week to avoid drowning of apple snail egg clusters.*
Wood stork/ wading birds	F	*WCA-3A (Dry Season Recession Rate): Strive to maintain a recession rate of 0.07 feet per week, with an optimal range of 0.06 to 0.07 feet per week, from January 1 to June 1.*
	G	*WCA-3A (Dry Season): Strive to maintain areas of appropriate foraging depths (5-25 cm) within the Core Foraging Area (CFA) (18.6 mile radius) of any active wood stork colony.*
	H	*WCA-3A (Dry Season): Strive to maintain areas of appropriate foraging depths (5-15 cm) within the CFA (7 to 9 mile radius) of any active white ibis or snowy egret colony.*

*Note: All stages for WCA-3A are as measured at WCA 3- gage average [WCA-3AVG] [Sites 63, 64, 65])

Table C.2.1-2. ERTP Ecological Targets (ET) Used to Evaluate Potential CEPP Effects on Threatened and Endangered species.

Species	ET	Description of PM
CSSS	1	*NP-205 (CSSS-A): Strive to reach a water level of less than or equal to 7.0 feet NGVD at NP-205 by December 31 for nesting season water levels to reach 6.0 feet NGVD by mid- March.*
	2	*Strive to maintain a hydroperiod between 90 and 210 days (3 to 7 months) per year throughout sparrow habitat to maintain marl prairie vegetation.*

*Note: All stages for WCA-3A are as measured at WCA 3- gage average [WCA-3AVG] [Sites 63, 64, 65])

USFWS, along with Dr. Wiley Kitchens (Ph.D. of the University of Florida), Phil Darby (Ph.D. of the University of West Florida), and Dr. Christa Zweig (Ph.D. of the University of Florida), developed a series of water depth recommendations for WCA 3A that addresses the needs of the snail kite, Florida apple snail, and vegetation characteristic of their habitat, along with a wood stork component that was developed by James Beeren and Mark Cook (Ph.D.) from the SFWMD (**Figure C.2.1-16**). This water management strategy is divided into three time periods representing the height of the wet season (September 15 to October 15), the pre-breeding season (January) and the breeding season (termed dry season low, May 1 to June 1) and illustrates appropriate water depths to attain within each time period. Water depth recommendations as measured at the WCA 3AVG proposed within the USFWS 2010 Draft Multi-Species Transition Strategy (MSTS) forming the basis for ERTP PMs and ETs. Please note that these water depths are not targets, but used as guidance and represent a compromise between the

needs of the three species. Inter-annual variability is extremely important in the management of the system to promote recovery of the species.

Regional Simulation Model – Glades Lower East Coast Service Area (RSMGL) model results were used to compare performance of action alternatives in relation to the ERTP PMs and ETs in order to select the alternative that best met the CEPP objectives. Microsoft Excel 2007 was used to analyze RSM results and create bar graphs to graphically compare action alternatives. All calculations are based upon the RSM 41-year POR from 1965 through 2005.

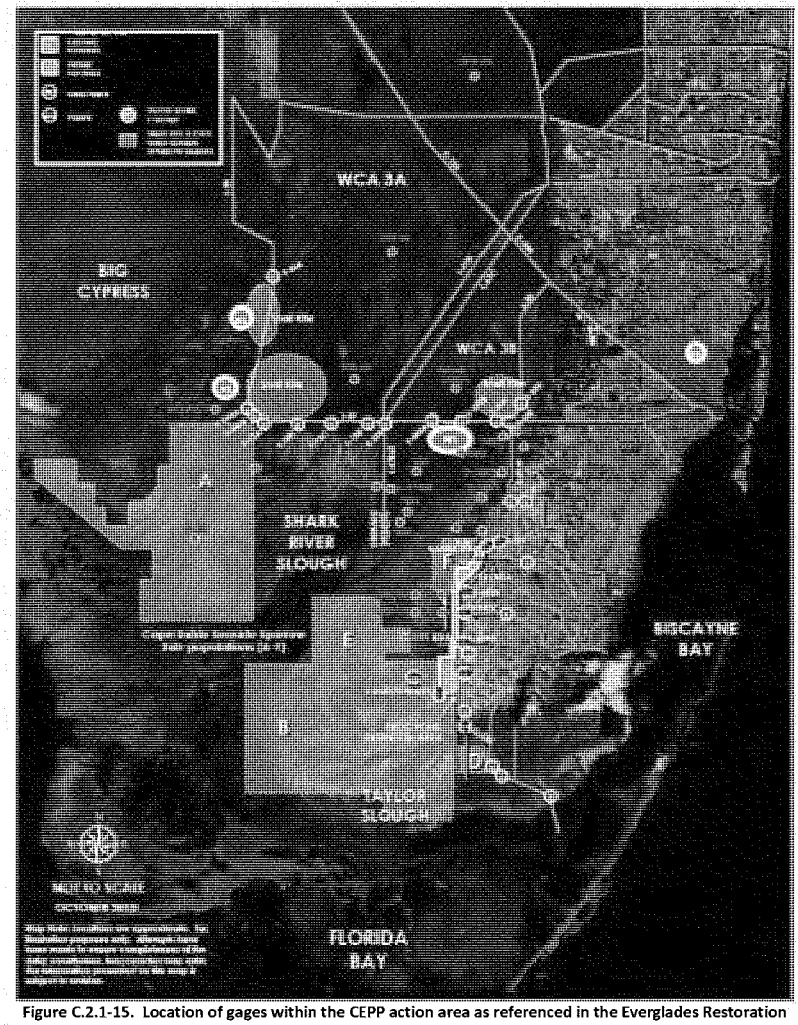


Figure C.2.1-15. Location of gages within the CEPP action area as referenced in the Everglades Restoration Transition Plan Performance Measures and Ecological Targets.

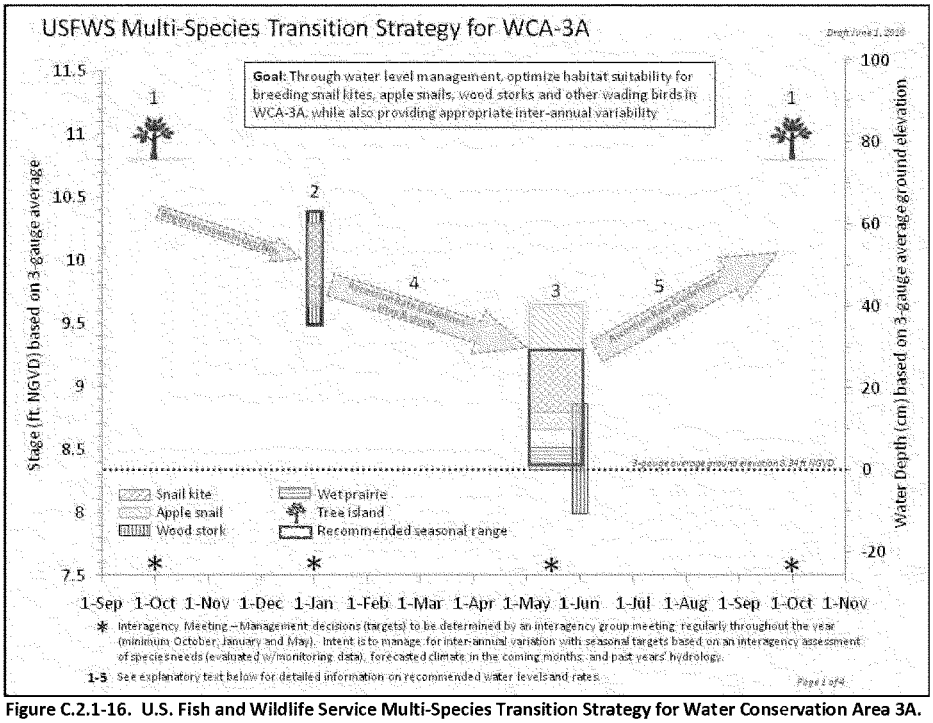


Figure C.2.1-16. U.S. Fish and Wildlife Service Multi-Species Transition Strategy for Water Conservation Area 3A.

C.2.1.4.1 Everglades Snail Kite

Snail kite habitat consists of freshwater marshes and the shallow vegetated edges of lakes where the apple snail (*Pomacea paludosa*), the snail kite's main food source, can be found. Snail kite populations in Florida are highly nomadic and mobile; tracking favorable hydrologic conditions and food supplies, and thus avoiding local droughts. Snail kites move widely throughout the primary wetlands of the central and southern portions of the State of Florida. Snail kite is threatened primarily by habitat loss and destruction. Widespread drainage has permanently lowered the water table in some areas. This drainage permitted development in areas that were once snail kite habitat. In addition to loss of habitat through drainage, large areas of marsh are heavily infested with water hyacinth, which inhibits the snail kite's ability to see its prey (USFWS 1986).

The snail kite has a highly specialized diet typically composed of apple snails, which are found in palustrine, emergent, long-hydroperiod wetlands. As a result, the snail kite's survival is directly dependent on the hydrology and water quality of its habitat (USFWS 1999). Snail kites require foraging areas that are relatively clear and open in order to visually search for apple snails. Suitable foraging habitat for the snail kite is typically a combination of low profile marsh and a mix of shallow open water. Shallow wetlands with emergent vegetation such as spike rush (*Eleocharis* spp.), maidencane, sawgrass, and other native emergent wetland plant species provide good snail kite foraging habitat as long as the vegetation is not too dense to locate apple snails. Dense growth of plants reduces the ability of the snail kite to locate apple snails and their use of these areas is limited even when snails are in relatively high

abundances (Bennetts et al. 2006). Areas of sparse emergent vegetation enable apple snails to climb near the surface to feed, breathe, and lay eggs and thus they are easily seen from the air by foraging snail kites. Suitable foraging habitats are often interspersed with tree islands or small groups of scattered shrubs and trees which serve as perching and nesting sites.

Snail kite nesting primarily occurs from December to July, with a peak in March-June, but can occur year-round. Nesting substrates include small trees such as willow, cypress (*Taxodium* spp.) and pond apple, and herbaceous vegetation such as sawgrass, cattail, bulrush (*Scirpus validus*) and reed (*Phragmites australis*). Snail kites appear to prefer woody vegetation for nesting when water levels are adequate to inundate the site (USFWS 1999). Nests are more frequently placed in herbaceous vegetation during periods of low water when dry conditions beneath willow stands (which tend to grow to at higher elevations) prevent Snail kites from nesting in woody vegetation (USFWS 1999). It is rare for a nest to collapse (not survive) in woody vegetation but common in non-woody vegetation, especially on lake margins (USFWS 1999). In order to deter predators, nesting almost always occurs over water (Sykes 1987a; Sykes et al. 1995).

Rehydration and vegetation shifts within northern WCA 3A and increased hydroperiods within ENP is likely to increase suitable habitat for apple snails, thereby increasing spatial extent of suitable foraging opportunities for snail kites providing a moderate beneficial effect. Based on this single metric, in WCA 3B, Alt 4 performed the best overall, followed by, Alts 3, 1, and 2 respectively; however, a more defined operational plan could equalize the performance between plans.

Apple snail egg production is maximized when dry season low water levels are less than 40 centimeters but greater than 10 centimeters (Darby et al. 2002; USFWS 2010). Overall, Alt 4 was the only alternative that showed improvement over the FWO in the number of years when the water depth was less than 40 cm before April 1 (**Table C.2.1-3**) (see **Figure C.2.1-17** for gage locations).

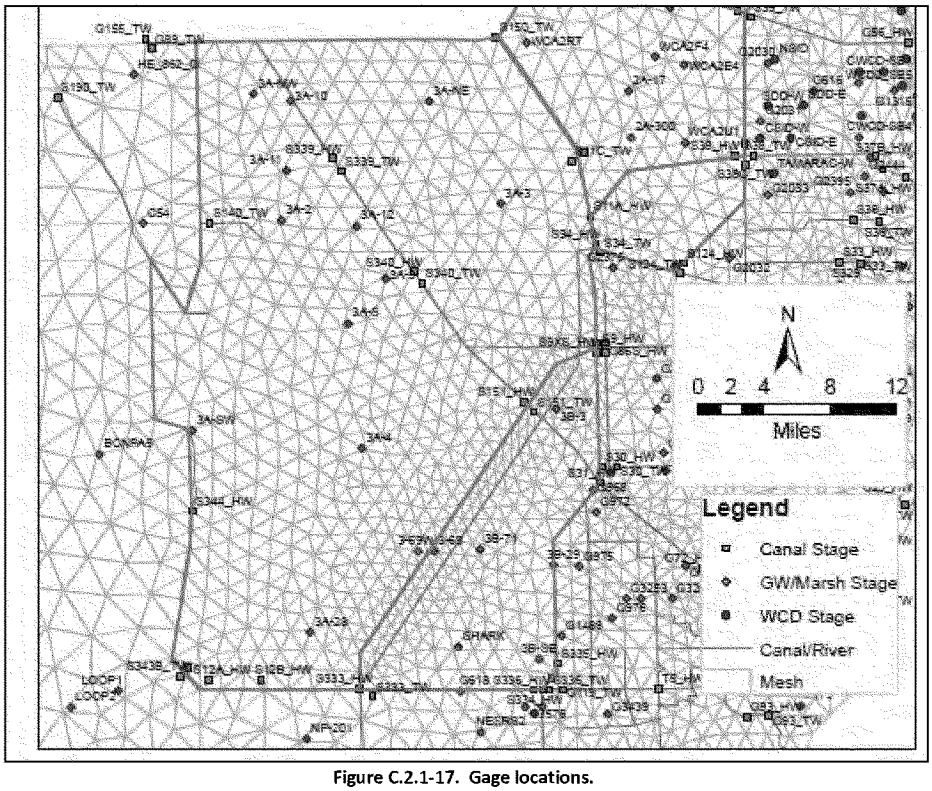


Figure C.2.1-17. Gage locations.

Table C.2.1-3 Number of years in POR met where water depths were less than 40cm before April 1. This metric is important for maximizing apple snail production.

April < 40 cm						
	ECB	**FWO**	**ALT-1**	**ALT-2**	**ALT-3**	**ALT-4**
Gage	3A-NE					
# years met	40	40	39	39	39	39
Gage	3A-NW					
# years met	40	40	24	36	36	36
Gage	3A-3					
# years met	35	36	35	35	35	35
Gage	3A-4					
# years met	33	34	**31**	**32**	33	32
Gage	3A-28					
# years met	12	15	16	17	17	16
Gage	3A-SW					
# years met	39	39	39	39	39	39
Gage	3B-71					
# years met	31	32	35	32	36	36
Gage	3BS1W1					
# years met	18	22	23	12	16	31
Total	**248**	**258**	**242**	**242**	**251**	**264**

The totals in **Table C.2.1-4** represent the total of all gages in meeting the apple snail depth requirements for the 41 year POR. All 4 alternative plans should lead to increased apple snail populations in northern WCA 3A. Alternatives 3 and 4 suggest that they could provide appropriate conditions for getting more apple snails into ENP compared to Alts 1 and 2 (**Table C.2.1-4**).

Table C.2.1-4. Number of years met for apple snail depth range

	May 1- June 1						31-Dec					
	ECB	FWO	ALT-1	ALT-2	ALT-3	ALT-4	ECB	FWO	ALT-1	ALT-2	ALT-3	ALT-4
Gage	3A-NE											
# years met	26	27	11	11	11	11	13	15	4	2	2	2
Gage	3A-NW											
# years met	8	6	20	25	25	25	0	0	17	5	5	5
Gage	3A-3											
# years met	15	9	22	22	22	22	15	11	10	10	11	11
Gage	3A-4											
# years met	20	18	24	23	23	24	15	22	24	22	24	24
Gage	3A-28											
# years met	15	18	17	18	18	18	4	5	3	4	4	3
Gage	3A-SW											
# years met	6	4	9	7	7	7	5	2	0	0	0	0
Gage	3B-71											
# years met	24	23	27	26	29	30	5	5	5	11	5	3
Gage	3BS1W1											
# years met	14	13	18	11	13	17	19	18	26	12	31	20
Total	**128**	**118**	**148**	**143**	**148**	**154**	**76**	**78**	**89**	**66**	**82**	**68**

In conclusion, snail kite habitat would increase with all CEPP action alternatives and provide moderate and significant beneficial effects.

C.2.1.4.2 Cape Sable Seaside Sparrow

Presently, the known distribution of the CSSS is restricted to two areas of marl prairies east and west of SRS in the Everglades region (within ENP and BCNP) and the edge of Taylor Slough in the Southern Glades Wildlife and Environmental Area in Miami-Dade County. CSSS surveys resulted in a range map that divided the CSSS into six separate subpopulations, labeled as A through F (**Figure C.2.1-18**), with CSSS-A as the only subpopulation west of SRS (Curnutt et al. 1998).

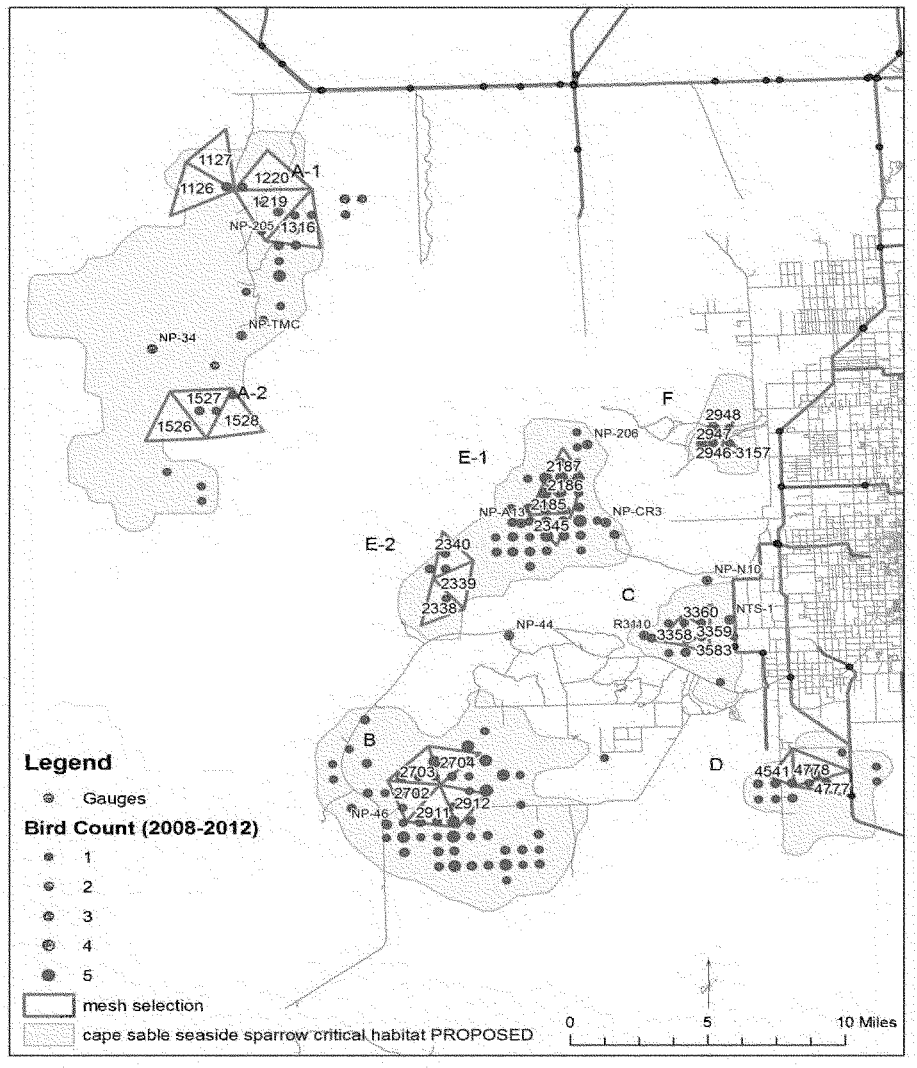


Figure C.2.1-18. Range of CSSS sub populations.

Effects of the action alternatives on the CSSS will be discussed below based on the appropriate PM.

PM-A NP-205 (CSSS-A): Provide a minimum of 60 consecutive days at NP-205 below 6.0 feet, NGVD beginning no later than March 15.

Cape Sable seaside sparrows build nests low to the ground around 14-17 cm. Male CSSS call for mates and set up territories when water levels drop below ground surface. Breeding behavior can be interrupted when water levels rise above ground surface. That is why it is important to maintain water levels below the ground surface for at least 60 days during the nesting season from March 1 to July 15. In order to compare action alternatives in relation to PM-A, the RSMGL simulated NP-205 daily stage was utilized. From this data, the number of consecutive dry days within the CSSS nesting window of March 1 through July 15 is counted. From this data, the number of years (N=41) that NP-205 was less than 6.0 feet, NGVD by March 15 was calculated (**Table C.2.1-5**) and is depicted in **Figure C.2.1-19**. **Table C.2.1-5** and **Figure C.2.1-19** compare the final array of alternatives with the FWO for 60 consecutive dry days at NP-205 between March 15 and July 15. There is little difference between the action alternatives, though Alt 2 performed slightly better than the other alternatives. However, there are differences between the action alternatives and the FWO in all action alternatives. The northern portion of the area occupied by CS5S-A and CSSS-F show a minor beneficial effect over FWO. The northern region within CSSS-A had 22-23 years met in the alternatives compared to 20 years met in the FWO. CSSS- F had 34-36 years met with the alternatives compared to 33 years met in the FWO. The southern region of CSSS- A and CSSS-E show a minor adverse effect compared to the FWO. The southern region of CSSS-A had 22-25 years met in the alternatives compared to 33 years met in the FWO. CSSS-E had 33-34 years met with the alternatives compared to 36 years met in the FWO. **Figure C.2.1-20**, **Figure C.2.1-21** and **Figure C.2.1-22** compare the duration of consecutive dry days between the alternatives and the FWO for the northern and southern regions of CSSS-A and CSSS-E, respectively, since this is where there were significant differences between the alternatives and the FWO. In the northern region of CSSS-A, there is very little difference between alternatives and a slight increase in the duration over the FWO (**Figure C.2.1-20**). However, in the southern region of CSSS-A, the FWO has significantly greater durations of dry periods over 60 days than any of the alternatives (**Figure C.2.1-21**). In CSSS-E, the FWO has a greater duration of consecutive dry days over 60 days than any of the alternatives (**Figure C.2.1-22**).

Table C.2.1-5. PM-A number of years there is a minimum of 60 consecutive days at NP-205 below 6.0 feet, NGVD beginning no later than March 15.

Sub Pop	Gage/Cell	Alt 1	Alt 2	Alt 3	Alt 4	FWO
A	IR-A1	22	23	22	22	20
	IR-A2	25	23	23	22	33
	P34	29	28	27	27	29
	TMC	28	29	26	28	32
B	CY3	40	40	40	40	40
C	R3110	39	39	39	39	39
	E112	38	39	38	40	38
D	EVER4	21	22	21	21	22
E	NE of NPA13	34	34	33	34	36
F	NE of RG2	36	35	34	35	33

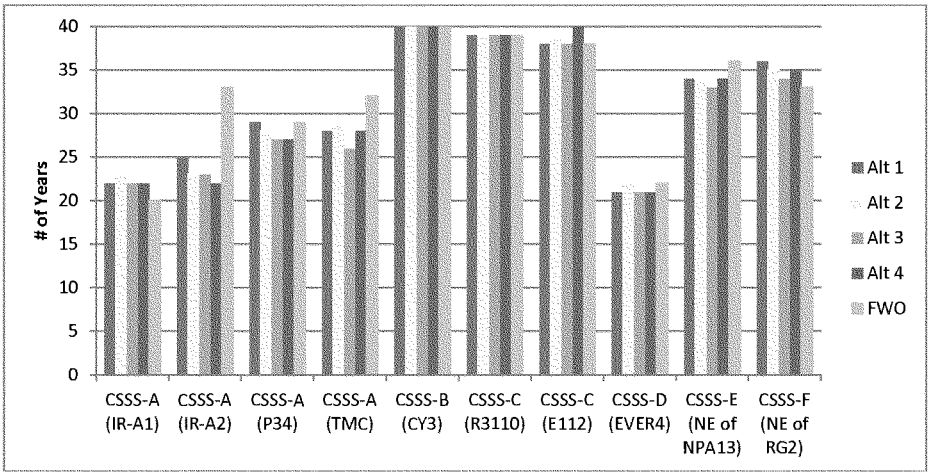


Figure C.2.1-19. PM-A: number of years a minimum of 60 consecutive days at NP-205 below 6.0 feet, NGVD beginning no later than March 15 is met out of the 40 year period of record.

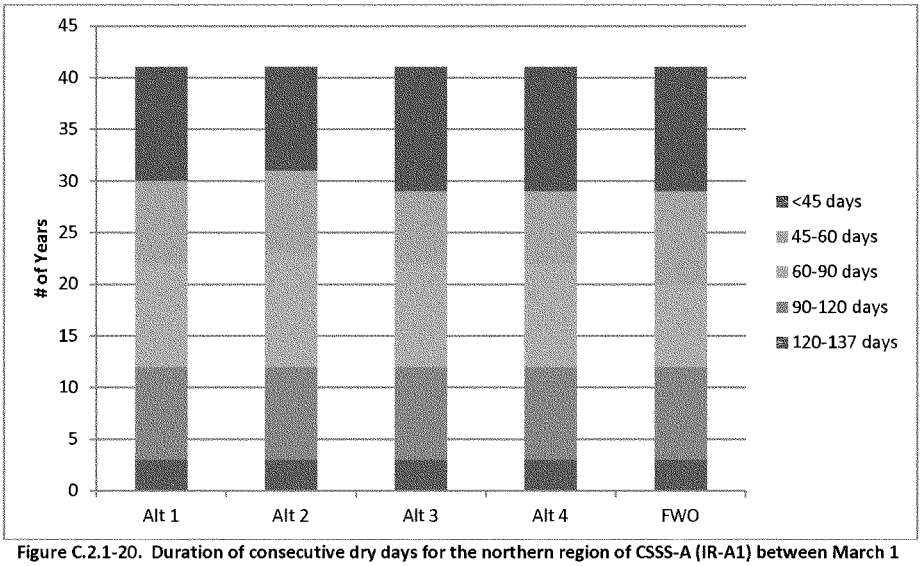


Figure C.2.1-20. Duration of consecutive dry days for the northern region of CSSS-A (IR-A1) between March 1 and July 15.

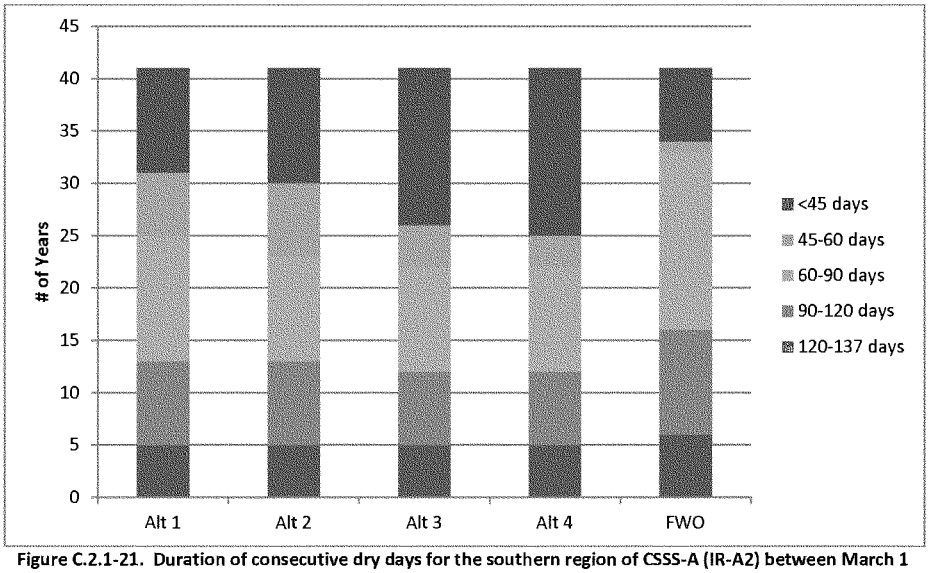


Figure C.2.1-21. Duration of consecutive dry days for the southern region of CSSS-A (IR-A2) between March 1 and July 15.

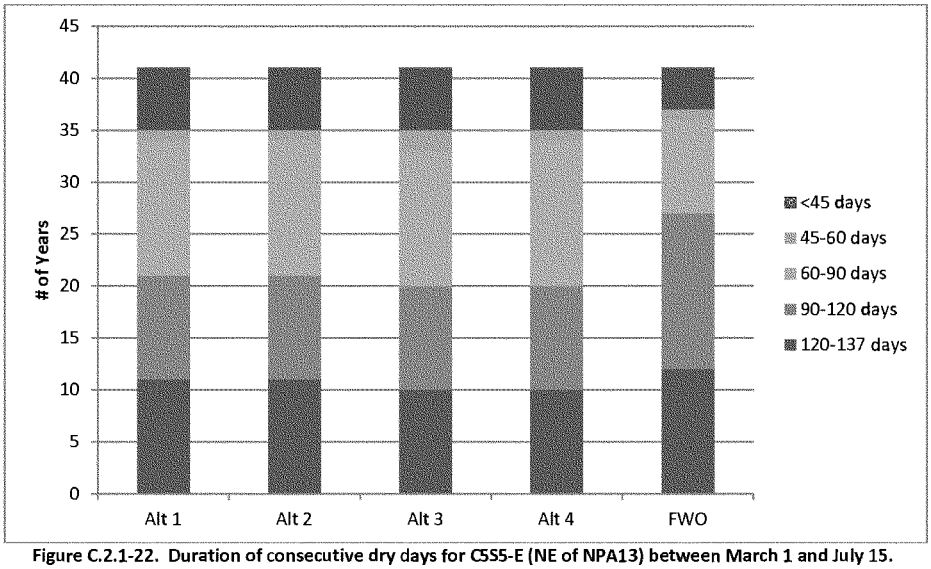


Figure C.2.1-22. Duration of consecutive dry days for C5S5-E (NE of NPA13) between March 1 and July 15.

ET-1 (NP-205, CSSS-A): Strive to reach a water level of less than or equal to 7.0 feet, NGVD at NP-205 by December 31 for nesting season water levels to reach 6.0 feet, NGVD by mid-March.
As illustrated by **Figure C.2.1-23**, ET-1 would have been achieved in 97 percent of years (39 of 40 years) under each of the CEPP action alternatives and the FWO.

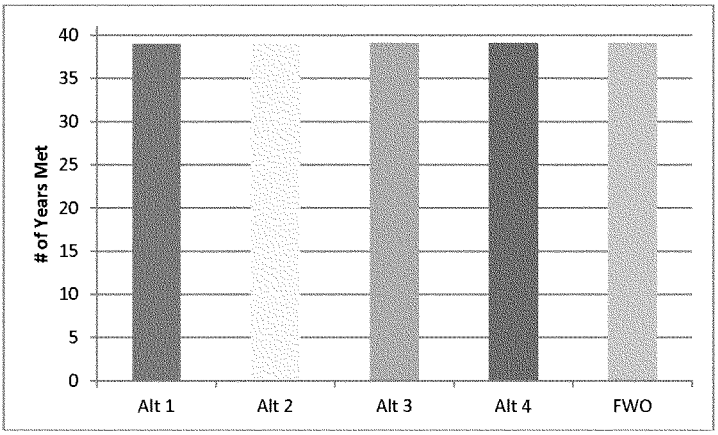


Figure C.2.1-23. ET-1 Number of years over the POR where water levels were at or below 7.0 ft at NP-205 by December 31 for nesting season water levels to reach 6.0 feet by mid-March for the four action alternatives and the FWO.

ET-2 (CSSS): Strive to maintain a hydroperiod between 90 and 210 days (three to seven months) per year throughout sparrow habitat to maintain marl prairie vegetation.

To maintain suitable habitat for CSSS, the annual hydroperiod (i.e., time above ground surface during wet season) should be between 90 and 210 days. Sparrows prefer to nest in short-stature clumped grasses such as *Muhlenbergia*, *Schizachryium*, and *Schoenus.* Habitat can tolerate infrequent years of up to 240 days and below 90 days. In order to compare action alternatives for hydroperiod throughout CSSS habitat, ETs were employed. RSM-GL results for each CSSS subpopulation are depicted in **Table C.2.1-6** and **Figure C.2.1-24** through **Figure C.2.1-35**. **Table C.2.1-6** and **Figure C.2.1-24** compare the final array of alternatives with FWO to maintain a hydroperiod between 90 and 210 days (three to seven months) per year throughout sparrow habitat to maintain marl prairie vegetation. In Northern Sub population A, all action alternatives perform the same and better than the FWO (10 years met compared to 6 years met in FWO) having a negligible or minor beneficial effect. In the southern Sub population A, all action alternatives perform the same, but slightly worse than FWO (8 years met compared to 9 years met in FWO) having a negligible or minor adverse effect. In Sub population B Alts 1, 3, and 4 perform slightly worse (24 years met) than Alt 2 and FWO (25 years met) having a negligible or minor adverse effect. In Sub population C, Alts 3 and 4 perform slightly better (20 years met) than Alt 2 and FWO (19 years met). Alternative 1 performs slightly worse (18 years met) than FWO (19 years met). In sub population D, Alts 2, 3, 4 and FWO performed slightly better (16 years met) than alternative 1 (15 years met). In sub population F, alternative 1 performed slightly better (20 years met) than alternatives 2 and 3 (19 years met), which performed slightly better than Alternative 4 and FWO (18 years met).

Table C.2.1-6. Number of years out of the period of record that the hydroperiod was between 90 and 210 days (three to seven months) each year throughout sparrow habitat in order to maintain marl prairie vegetation.

CSSS Sub Population	*Alt 1*	*Alt 2*	*Alt 3*	*Alt 4*	*FWO*
Northern A	10	10	10	10	6
Southern A	8	8	8	8	9
B	24	25	24	24	25
C	18	19	20	20	19
D	15	16	16	16	16
Northern E	19	19	19	19	24
Southern E	9	9	9	9	12
F	20	19	19	18	18

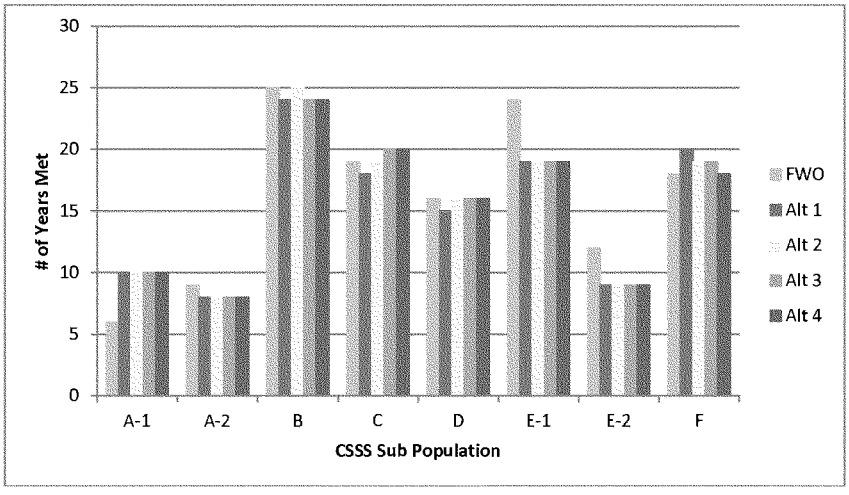


Figure C.2.1-24. Number of years out of the period of record that the hydroperiod was between 90 and 210 days (three to seven months) each year throughout sparrow habitat in order to maintain marl prairie vegetation.

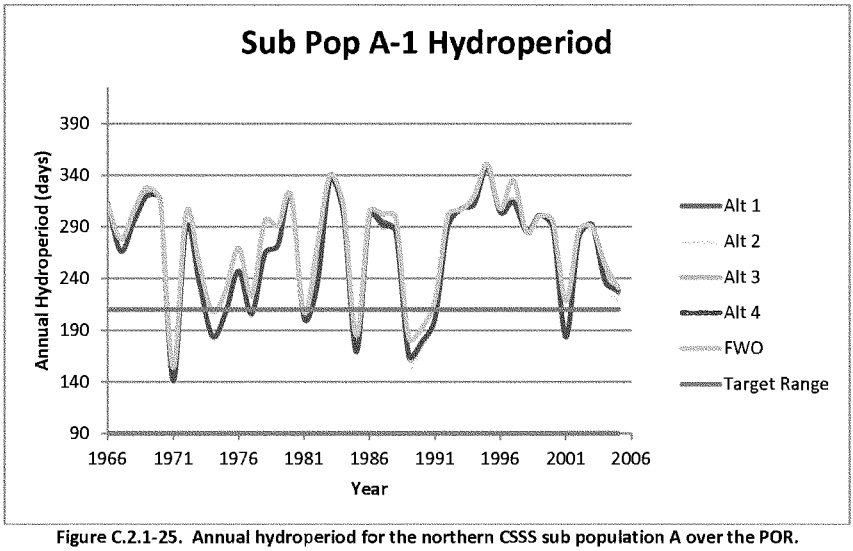


Figure C.2.1-25. Annual hydroperiod for the northern CSSS sub population A over the POR.

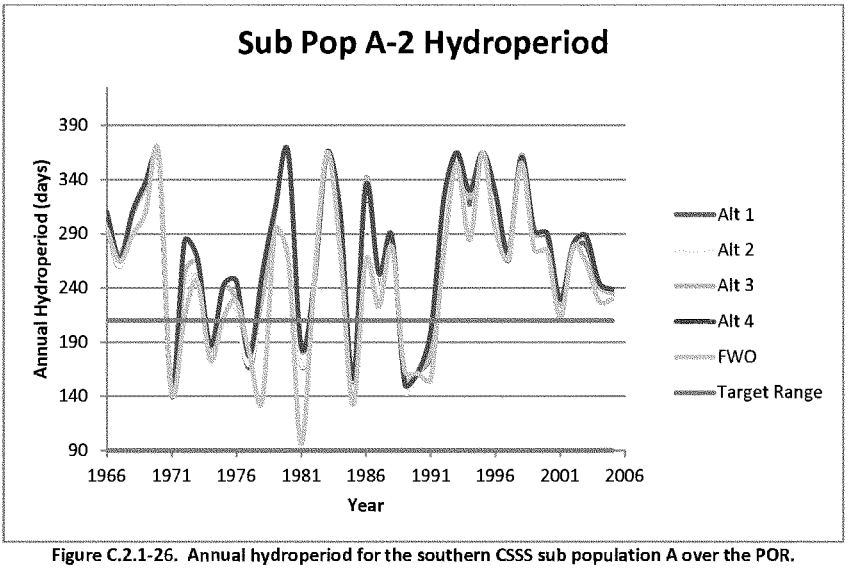


Figure C.2.1-26. Annual hydroperiod for the southern CSSS sub population A over the POR.

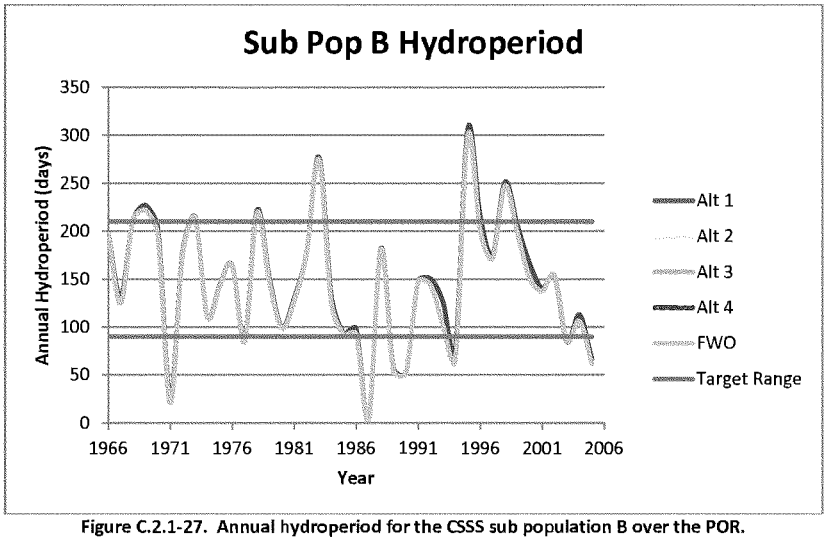


Figure C.2.1-27. Annual hydroperiod for the CSSS sub population B over the POR.

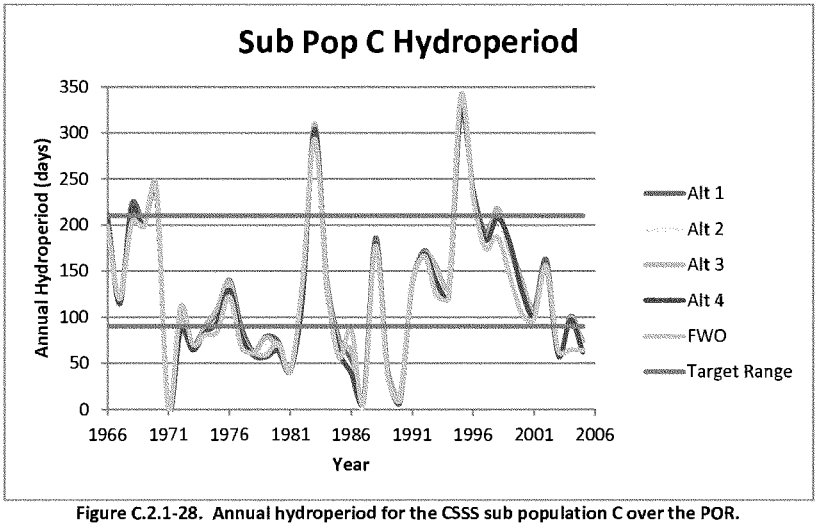


Figure C.2.1-28. Annual hydroperiod for the CSSS sub population C over the POR.

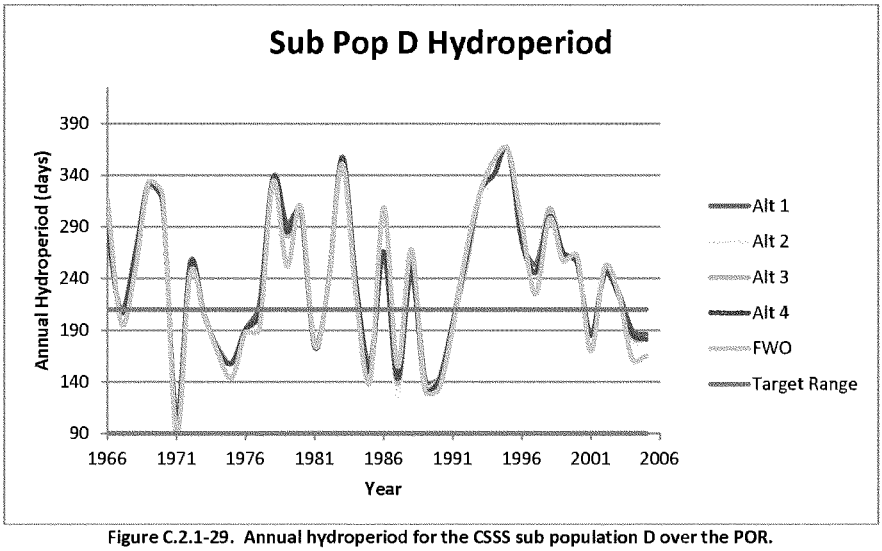


Figure C.2.1-29. Annual hydroperiod for the CSSS sub population D over the POR.

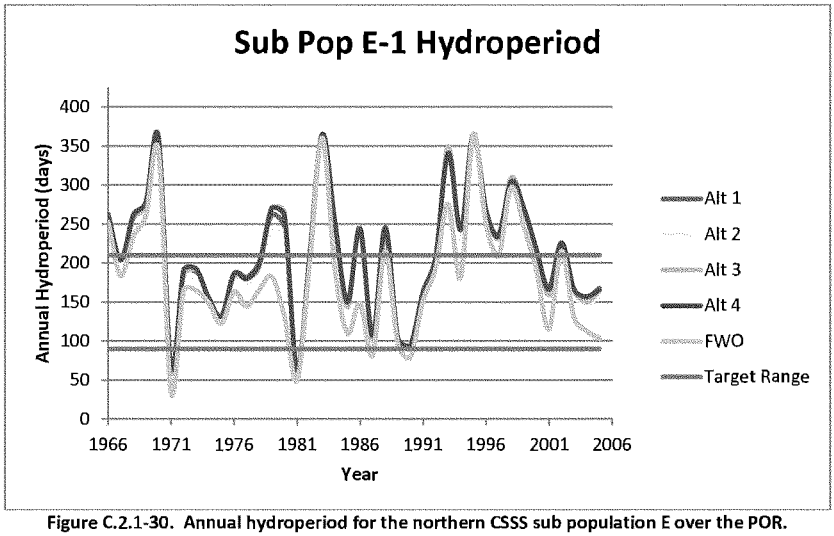


Figure C.2.1-30. Annual hydroperiod for the northern CSSS sub population E over the POR.

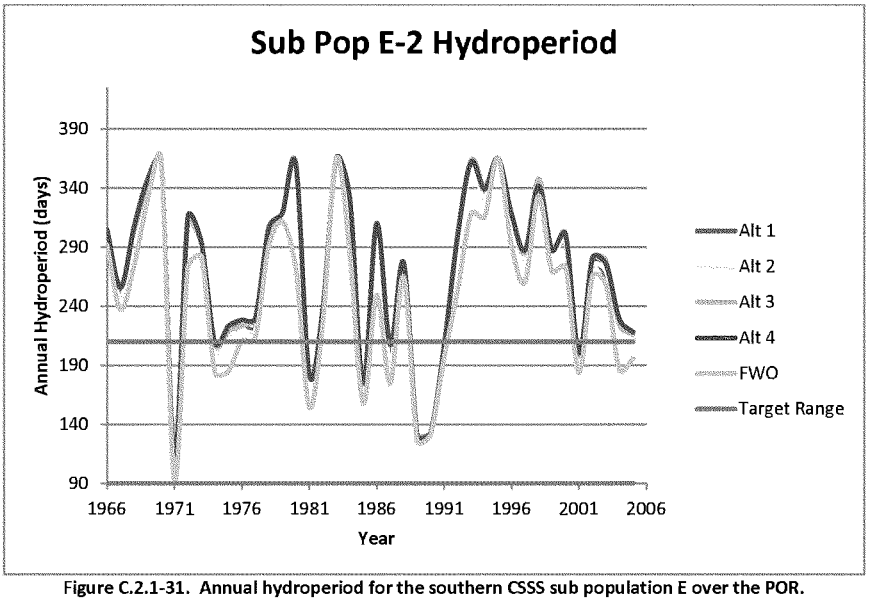


Figure C.2.1-31. Annual hydroperiod for the southern CSSS sub population E over the POR.

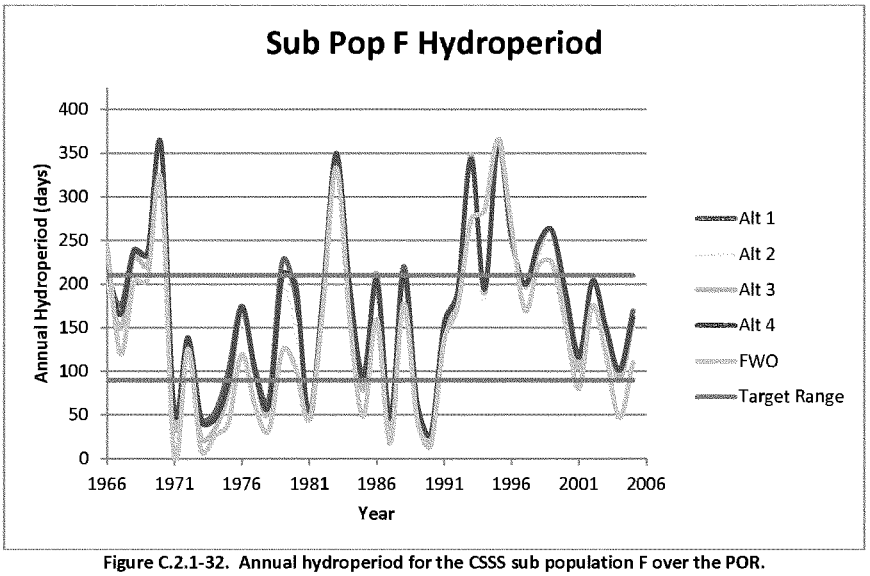


Figure C.2.1-32. Annual hydroperiod for the CSSS sub population F over the POR.

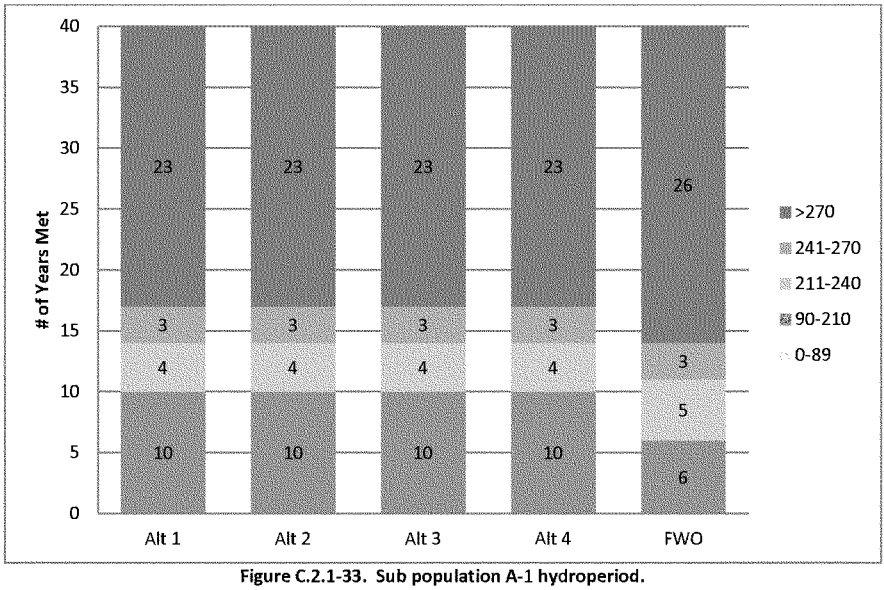


Figure C.2.1-33. Sub population A-1 hydroperiod.

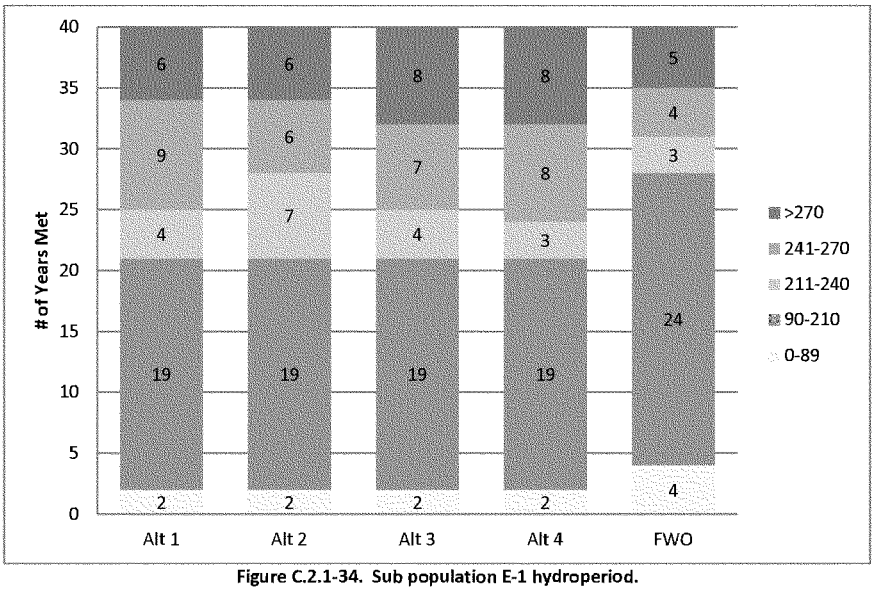


Figure C.2.1-34. Sub population E-1 hydroperiod.

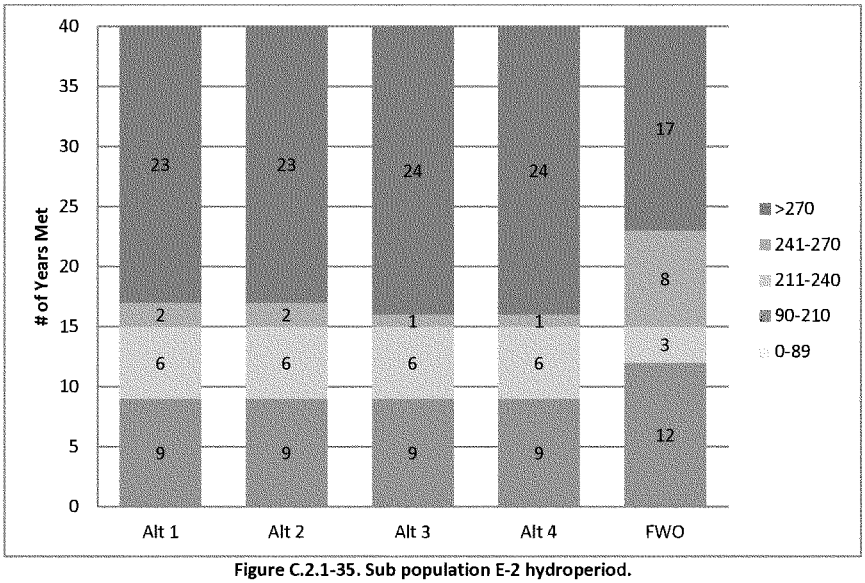


Figure C.2.1-35. Sub population E-2 hydroperiod.

In summary, implementation of any action alternative, with currently defined operations, has the potential to provide a major adverse affect and a significant and unavoidable effect on hydroperiods within the marl prairies adjacent to NESRS. Longer hydroperiods than the FWO are predicted within CSSS-E and southern portions of CSSS-A. Hydroperiods within northern CSSS-A are slightly reduced over the FWO, providing slightly better, but overall too wet conditions for marl prairie habitat and nesting CSSS. Alt 2 is slightly better performing overall, followed by Alts 1, 3, and 4. Nesting condition (or number of dry nesting days) proved to be a less sensitive metric than hydroperiod. Minor improvements were seen in northern CSSS-A and CSSS-F while performance was reduced in southern CSSS-A and E. Alternatives 1 and 2 were slightly better performing than Alts 3 or 4.

C.2.1.4.3 Wood Stork

Historically, the short hydroperiod wetlands within ENP have been important for wood stork foraging during the pre-breeding season with the storks shifting to longer hydroperiod wetlands as the dry season progresses. Hydrological patterns that produce a maximum number of patches with high prey availability (i.e. high water levels at the end of the wet season and low water levels at the end of the dry season) are necessary for high reproductive outputs (Gawlik 2002; Gawlik et al. 2004). Depending upon the elevation and microtopography throughout the WCAs and ENP, implementation of CEPP will produce a variety of wetland habitats that would support prey densities conducive to successful wading bird foraging and nesting.

Water depth and recession rate are the two most important hydrological variables for wood storks (Gawlik et al. 2004) and wading birds. In their analysis of habitat suitability, Gawlik et al. (2004) identified feeding sites where the weekly average water depths from November to April (pre-breeding and breeding season) were between 0.0 and 0.5 feet as the most suitable. Suitability drops to 0.0 when water depths are -0.3 feet below marsh surface or greater than 0.8 feet. Wood storks and other wading

birds require recession to condense their prey items into shallow pools for more effective foraging. It is recognized that areas of suitable foraging habitat will vary both within and between years due to microtopography, antecedent conditions, hydrological and meteorological conditions, and water management actions. It is anticipated that these provisions within CEPP will help to improve foraging conditions within WCA 3A and provide a direct benefit to the wood stork and other wading bird species. Implementation of all action alternatives would be expected to significantly improve conditions for wood storks throughout much of the Greater Everglades. Overall, Alts 3 and 4 perform the best in comparison with Alts 1 and 2.

Several models of wading birds were used to assess potential affects to wading birds within the Greater Everglades as a result of implementation of CEPP action alternatives including: 1) Wood Stork Foraging Probability Index model (South Florida Natural Resources Center 2013); 2) wading bird species distribution (Beerens 2013); and 3) wading bird nesting success (Beerens 2013). ERTP PMs are captured within the Beerens models.

An analysis of wood stork foraging potential was performed to predict improvements to foraging habitat with CEPP implementation (South Florida Natural Resources Center 2013b). The Wood Stork Foraging Probability Index (STORKI v. 1.0) was developed to provide rapid simulations of wood stork foraging conditions in response to modeled CERP scenarios (LoGalbo et al. 2012). The Wood Stork Foraging Probability Index indicates that northeastern WCA 3A and Miami Canal show the most substantial improvements to foraging habitat with all action alternatives performing between 70% to 130% better than FWO and providing moderate beneficial effects (**Figure C.2.1-36**). Improvements are also seen in northwestern WCA 3A, WCA 3B and southern ENP. Alternative 1 does not perform as well in northwestern WCA 3A as the other alternatives, portions of this area remain too wet during some portions of the breeding season. Alternatives 3 and 4 provided 50% to 68% more foraging habitat in WCA 3B and southern ENP respectively. However, in WCA 3B, Alt 2 appears to create conditions that are generally too wet for optimal foraging in most years. All action alternatives performed worse than the FWO in northern ENP (-85%) and WCA 3A South (up to -20%).

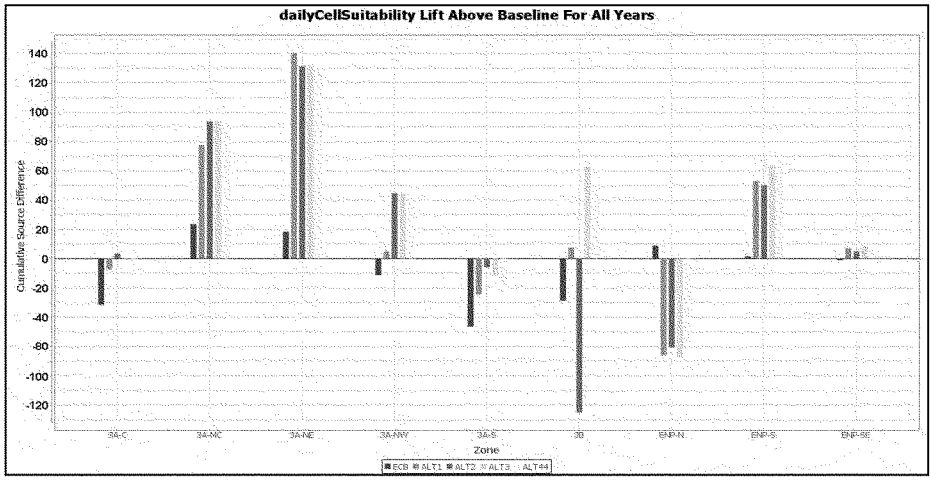


Figure C.2.1-36. Wood stork suitable habitat cumulative (1965-2005) lift above FWO for the action alternatives within each CEPP zone. A maximum score of 1327 is possible if FWO has a suitability score of 0.0 every week and the alternative has a suitability score of 1.0 every week of the 41 year hydrologic model runs. (South Florida Natural Resources Center 2013b)

The situation is less obvious than it appears in **Figure C.2.1-37** for northern ENP. **Figure C.2.1-38** illustrates weekly suitability scores for all the action alternatives at ENP N. FWO exhibits a wide fluctuation of suitability scores over the breeding season. The gravity-driven flowway of Alt 4 results in even larger score fluctuations. High scores are sometimes offset from FWO/ECB, and Alt 4 high foraging scores substantially exceed those of FWO or any of the other alternatives. Alternatives 1, 2, and 3, in contrast, moderate both the highs and lows and, in doing so, reduce the overall foraging suitability for wood stork, as is reflected in **Figure C.2.1-37**. **Figure C.2.1-38** is substantially misleading with respect to Alt 4. Rather than being less desirable than FWO, Alt 4 substantially improves habitat during appropriate parts of the season and reflects a more natural system dynamic over the entire season providing moderate beneficial effects. For comparison, **Figure C.2.1-39** plots the weekly time series of foraging suitability for the Miami Canal CEPP zone. Here, all of the action alternatives are in close agreement and generally, though not always, exceed FWO. (South Florida Natural Resources Center 2013b)

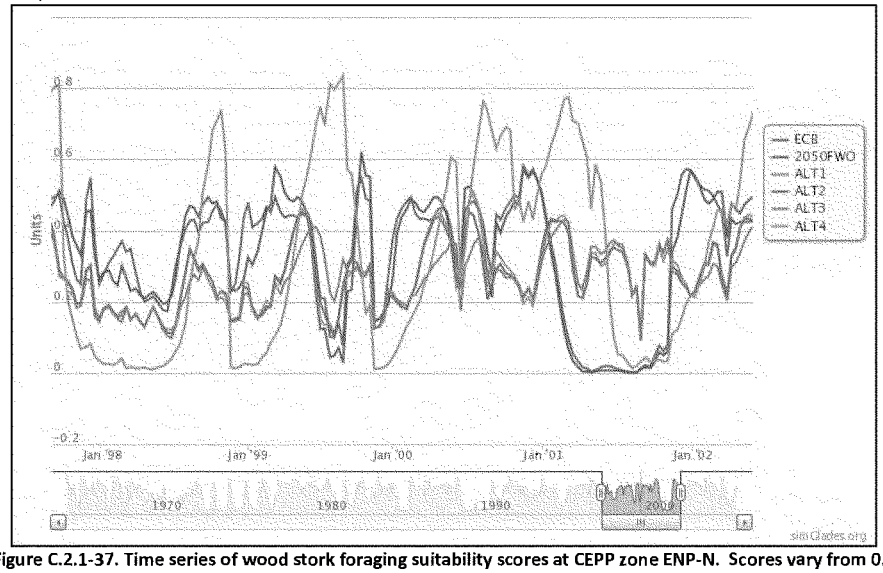


Figure C.2.1-37. Time series of wood stork foraging suitability scores at CEPP zone ENP-N. Scores vary from 0.0 (not suitable) to 1.0 (optimal foraging). To improve clarity, the plot focuses on an abridged time period between July 1997 and July 2002. Other time periods have similar relationships among the action alternatives. (South Florida Natural Resources Center 2013b)

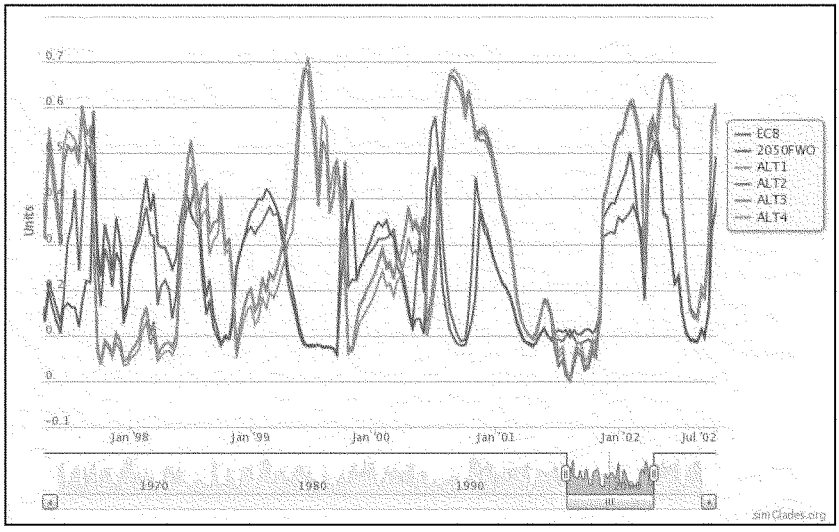


Figure C.2.1-38. Time series of wood stork foraging suitability scores at CEPP zone WCA3A-MC. (South Florida Natural Resources Center 2013b)

When scores are aggregated by WCA the trends are similar (**Figure C.2.1-39**), but lifts are compressed by aggregation over a larger area. **Figure C.2.1-39** includes the addition of WCA 2 and WCA 1 which are outside CEPP action area. WCA 2 has a small (1%) loss of forage suitability resulting from water being redirected from WCA 2 to WCA 3A. WCA 1 foraging suitability change is negligible (ENP 2013).

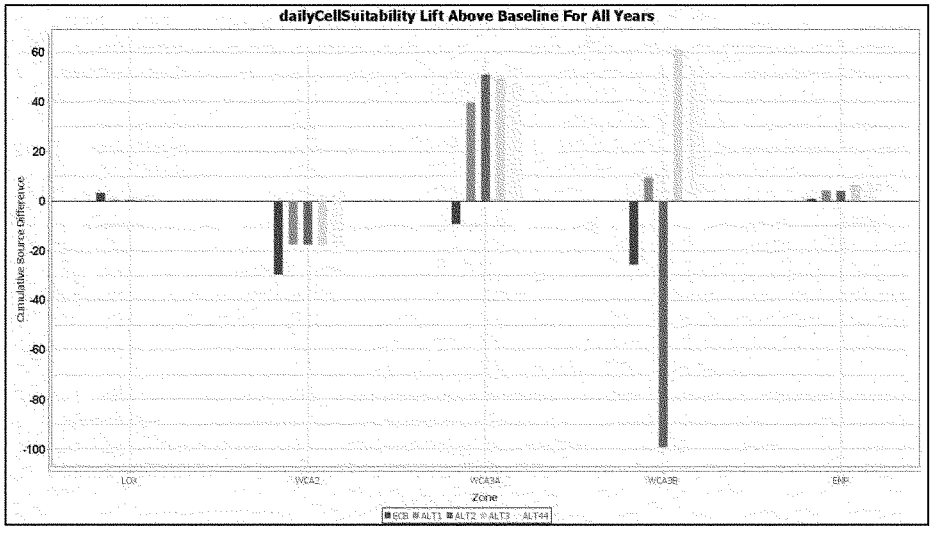


Figure C.2.1-39. Wood stork suitable habitat cumulative (1965-2005) lift above FWO for the action alternatives within each water conservation area (WCA) and ENP. (South Florida Natural Resources Center 2013b)

Wood stork, white ibis, and great egret species distribution were modeled by Beerens et al. 2013 in support of the RECOVER Greater Everglades ecological evaluation. Wood storks generally showed increased numbers in northern WCA 3A and southern ENP for the four action alternatives compared to the FWO. White ibis numbers were also greater in northern WCA 3A and southern ENP, but also in part of central WCA 3A for all action alternatives. The great egret model showed improvements in northern WCA 3A, southern ENP, Central WCA 3A, and WCA 3B, but also indicated reductions in presence in northern ENP.

The wading bird nesting models predict the number of nests for the wood stork, white ibis, and great egret species (Beerens 2013). All four action alternatives generally performed better for great egret, white ibis, and wood stork nesting than FWO providing moderate beneficial effects. In the northern Everglades each alternative showed fewer nests than FWO for white ibis and wood storks, but more nests than FWO for egrets. However, in the southern Everglades, the action alternatives performed better than FWO. The Great Egret nesting model showed the biggest benefit in raw numbers of nests but the Wood Stork model showed a more significant benefit relative to its population size (Beerens 2013). This pattern of better wading bird nesting in the southern Everglades than northern Everglades is not unexpected and is consistent with the prediction that nesting trends in a restored Everglades would increase in the coastal zone, rather than system wide (RECOVER 2009). In the southern Everglades, Alt 3 performed best for white ibis and great egret, whereas Alts 1 and 2 performed best for wood storks.

As compared with FWO, all CEPP action alternatives reveal the potential for significant, short-term negative effects to aquatic vegetation within Lake Okeechobee due to higher than preferred lake stages. As a result, temporary reductions in foraging habitat for shorebirds and short-legged wading birds could occur. However, these multiple day events in which Lake Okeechobee stage exceeded 15.0 feet NGVD occurred approximately 5% of the POR.

C.2.1.4.4 Eastern Indigo Snake

The Eastern indigo snake is the largest native non-venomous snake in North America. It is an isolated subspecies occurring in southeastern Georgia and throughout peninsular Florida. The Eastern indigo snake prefers drier habitats, but may be found in a variety of habitats from xeric sandhills, to cabbage palm hammocks, to hydric hardwood hammocks (Schaefer and Junkin 1990). Eastern indigo snakes need relatively large areas of undeveloped land to maintain their population. The main reason for its decline is habitat loss due to development. Further, as habitats become fragmented by roads, Eastern indigo snakes become increasingly vulnerable to highway mortality as they travel through their large territories (Schaefer and Junkin 1990).

In south Florida, the Eastern indigo snake is thought to be widely distributed. Given their preference for upland habitats, Eastern indigo snakes are not commonly found in great numbers in the wetland complexes of the Everglades region, even though they are found in pinelands, tropical hardwood hammocks, and mangrove forests in extreme south Florida (Duellman and Schwartz 1958; Steiner et al. 1983).

One of the CEPP project features in all action alternatives is a FEB in A-2. This would convert approximately 14,000 acres of former agricultural land to a wetland functioning area. The proposed A-2 FEB consists almost exclusively of drained marsh that has been converted to agriculture. Currently, the

main crop is sugar cane, although rice has also been observed in some fields. A few areas have become overgrown with exotic Brazilian pepper, willow, dog fennel, and grasses including invasive exotic Napier grass. Only two soil types occur in the project area: Pahokee Muck and Lauderhill Muck (NRCS 2012). Both types consist of very poorly drained organic materials that commonly occur in broad freshwater marshes. These soil types indicate hydric soils/wetland areas, which was originally in place prior to human actions. One of the CEPP goals is to help restore lands back to a more natural condition, which in the FEB area, would be considered wetlands.

No natural standing water features are present in the A-2 FEB project area. Natural sloughs and channels are evident in aerial photographs from the 1940s as well as those taken as recently as 2012. These natural sloughs and channels are much drier due to drainage changes, but are the first areas to be inundated during rains. Man-made drainage features such as ditches and narrow canals traverse the A-2 FEB and are continually being modified and created in response to agricultural needs.

Since Eastern indigo snakes occur primarily in upland areas, their presence within the Greater Everglades portion of the project area is somewhat limited. The hydrologic effects of the proposed project are expected to benefit existing or historic wetlands. Once the Miami Canal is backfilled, created tree islands will be constructed, which would potentially provide habitat for the indigo snakes, perhaps offsetting the increased hydroperiods within WCA 3. In addition, improvements to mangrove communities adjacent to Florida Bay may also benefit Eastern indigo snakes within those areas. However, eastern indigo snakes have a high probability of occurrence within the proposed A-2 FEB site and as a result of construction of the A-2 FEB are likely to be displaced, thereby removing approximately 14,000 acres of potential habitat and having a significant and unavoidable major adverse effect.

C.2.1.4.5 Florida Manatee

The federally endangered Florida manatee is a large, plant-eating aquatic mammal that can be found in the shallow coastal waters, rivers, and springs of Florida. Florida manatees live in freshwater, brackish, and marine habitats, and can move freely between salinity extremes. Florida manatees have been observed in conveyance canals within the action area, specifically in the lower C-111 Canal just downstream of S-197; and adjacent nearshore seagrass beds throughout Florida Bay including all waters of Card, Barnes, Blackwater, Little Blackwater, Manatee and Buttonwood sounds. The extensive acreages of seagrass beds in the bay provide important feeding areas for Florida manatees. Decreased salinities within the Northern Estuaries that reduce stress on SAV and promote increases in seagrass shoots have the potential to increase foraging opportunities for manatees in this region and provide a minor beneficial effect. Similarly, increased freshwater flows to Florida Bay and the southwestern coastal estuaries resulting in lowered salinity levels that better encompass seagrass salinity tolerance ranges would also increase foraging opportunities for manatees and provide a minor beneficial effect. Alternative 4 provides the greatest benefit, followed by Alts 3, 1 and 2 (refer to **Section C.2.1.3.5.2, Seagrass Beds** for further information).

Florida manatees also depend upon canals as a source of freshwater and resting sites. It is highly likely that Florida manatees also depend on the deep canals as a cold-weather refuge. The relatively deep waters of the canals respond more slowly to temperature fluctuations at the air/water interface than the shallow bay waters. Thus, the canal waters remain warmer than open bay waters during the passage of winter cold fronts. **Figure C.2.1-40** illustrates canals that Florida manatees have access to within CEPP action area. All CEPP action alternatives include backfilling of portions of the Miami Canal north of Interstate 75. Although **Figure C.2.1-40** shows that manatees can access portions of the Miami Canal, backfilling as described under CEPP is not likely to adversely affect manatees.

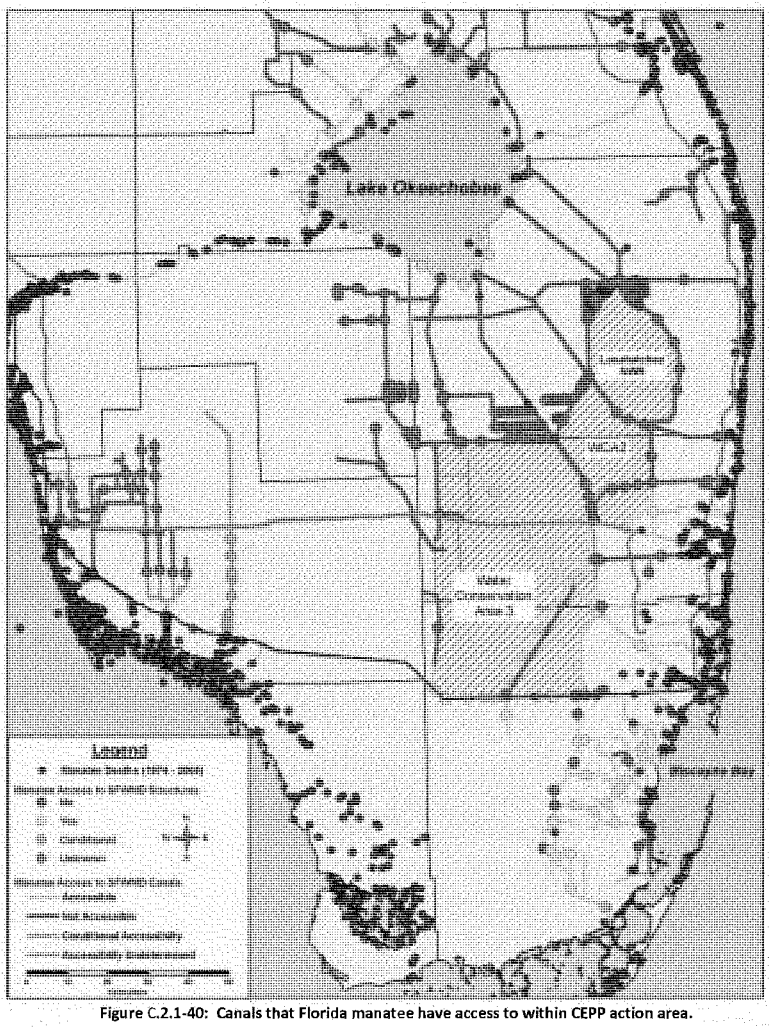


Figure C.2.1-40: Canals that Florida manatee have access to within CEPP action area.

C.2.1.4.6 Florida Panther

The federally endangered Florida panther (*Puma concolor cory)* was once the most widely distributed mammal (other than humans) in North and South America, but it is now virtually exterminated in the eastern United States. Habitat loss has driven the subspecies known as the Florida panther into a small area, where the few remaining animals are highly inbred, causing such genetic flaws as heart defects and sterility. Recently, closely-related panthers from Texas were released in Florida and are successfully breeding with the Florida panthers. Increased genetic variation and protection of habitat may save the subspecies. Florida panthers presently inhabit lands in ENP adjacent to the Southern Glades, and radio tracking studies have shown that they venture into the Southern Glades on occasion during post-breeding dispersion. Reference is made to the revised Panther Key and Panther Focus Area Map for use in determining effects to the Florida panther.

All action alternatives have the potential to have a minor adverse effect on both the Primary and Secondary Zones for Florida panther habitat. Construction of the 14,000 acre FEB within the A-2 parcel in EAA would result in conversion of upland habitat that could be potentially used by Florida panther to transverse the area to wetland habitat, thereby eliminating potential habitat within the panther secondary zone in this region.

Since potentially suitable habitat occurs within the action area, increased water deliveries under all CEPP action alternatives to ENP could affect Florida panther habitat, with the greatest potential affects viewed under Alts 4 and 3. However, as lands within CEPP action area become restored to their more historic natural values, the concomitant improved prey base would result in greater use by the Florida panther utilizing these areas. Based on this information, and the fact that the Florida panther is a wide-ranging species with the majority of sightings west of the action area, the proposed action may affect the Florida panther.

C.2.1.4.7 American Alligator

A keystone species within the Everglades ecosystem, the American alligator (*Alligator mississippiensis*) is dependent on spatial and temporal patterns of water fluctuations that affect courtship and mating, nesting, and habitat use (Brandt and Mazzotti 2000). Historically, American alligators were most abundant in the peripheral Everglades marshes and freshwater mangrove habitats, but are now most abundant in canals and the deeper slough habitats of the central Everglades. Water management practices including drainage of peripheral wetlands and increasing salinity in mangrove wetlands as a result of decreased freshwater flows has limited occurrence of American alligators in these habitats (Craighead 1968, Kushlan 1990, Mazzotti and Brandt 1994). A HSI for alligators was employed to predict potential effects of implementation of CEPP action alternatives. The HSI measures habitat suitability annually for five components of alligator production: (1) land cover suitability, (2) breeding potential (female growth and survival from April 16 of the previous year - April 15 of the current year), (3) courtship and mating (April 16 – May 31), (4) nest building (June 15 – July 15), and egg incubation (nest flooding from July 01 – September 15). (South Florida Natural Resources Center 2013a).

Results indicate that all CEPP action alternatives improve alligator habitat suitability as compared with FWO and provide a minor beneficial effect. Although the greatest improvements were seen in WCA3A with Alt 1, the results were not significantly different from those provided by Alts 4, 2 and 3 respectively. The greatest increase in benefits for all action alternatives as compared with FWO is visible within northern WCA 3A (CEPP Zones 3A-MC, 3A-NE and 3A-NW). All of the alternative plans improve alligator habitat by as much as 20% (**Figure C.2.1-41**) due to additional water deliveries within this region. In northwestern WCA 3A, Alt 1 provided the greatest increase in habitat suitability as compared with Alts

2, 3 and 4, which is likely due to the location of the western spreader canal concentrating flow within that region. Gains are smaller in central WCA 3A, WCA 3B, and northern ENP with modest variations in which alternative best improves scores (**Figure C.2.1-42**). Changes within southern WCA 3A and south-eastern ENP are negligible and less than significant. In southern WCA 3A, Alt 1 performed best overall with a decline in habitat suitability viewed for Alt 3 as compared with FWO. In contrast, in WCA 3B, the greatest improvements over FWO were viewed in order of greatest improvement with Alt 3, 2, 1 and 4. Within ENP, Alts 4 and 3 provided the greatest benefit, respectively, as compared with Alts 2 and 1 which showed similar results. In summary, increasing freshwater flow through the Greater Everglades into ENP under all CEPP action alternatives would provide increased benefits to alligators within these habitats in comparison with FWO. (South Florida Natural Resources Center 2013a)

Major, significant and unavoidable adverse effects to alligators that utilize the Miami Canal would occur under all of the CEPP action alternatives due to backfilling of the Miami Canal. However, these effects are expected to be short-term as alligators will expand into other areas of suitable habitat created as a result of CEPP implementation. Alternatives 1 would provide the least impact to alligators within the Miami Canal due to lesser extent of backfill.

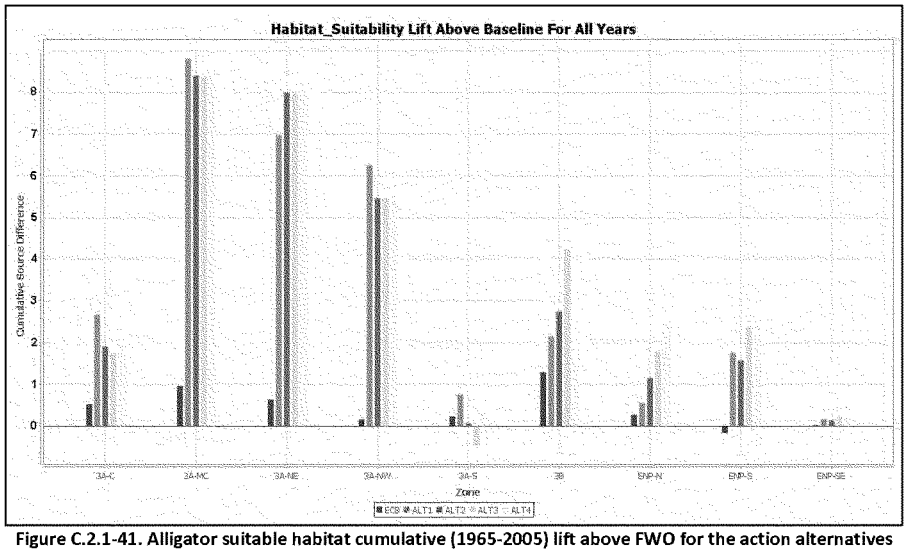


Figure C.2.1-41. Alligator suitable habitat cumulative (1965-2005) lift above FWO for the action alternatives within each CEPP zone. A maximum score of 41 is possible if FWO has a suitability score of 0.0 every year and the alternative has a suitability score of 1.0 every year. (South Florida Natural Resources Center 2013a)

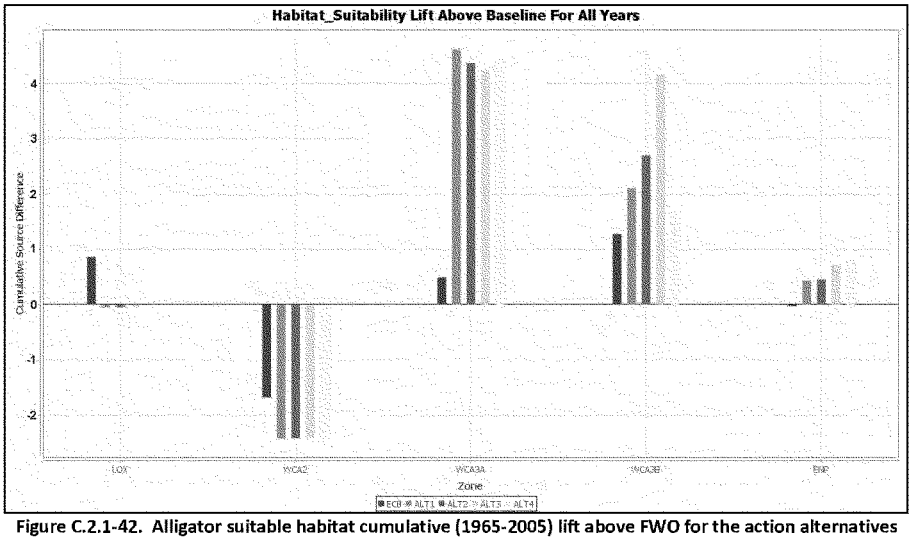


Figure C.2.1-42. Alligator suitable habitat cumulative (1965-2005) lift above FWO for the action alternatives within each water conservation area (WCA). (South Florida Natural Resources Center 2013a)

C.2.1.4.8 American Crocodile

A HSI for juvenile American crocodiles (*Crocodylus acutus*) was employed to predict potential effects of implementation of CEPP Alts 1-4 (Brandt 2013). The crocodile growth and survival index used in this analysis is one of the components of a crocodile HSI that characterizes suitable habitat for crocodiles based on habitat, location of known nest sites, salinity, and prey biomass. The growth and survival index is calculated for August through December, the period following hatching when hatchlings are most vulnerable to high salinities (Moler 1992; Mazzotti 1999; Mazzotti et al. 2007). For this analysis, data from salinity monitoring stations at Joe Bay, Trout Cove, Little Madeira Bay (the stations among the available stations closest to where the highest densities of crocodile nests are) and Long Sound, Little Blackwater Sound, Terrapin Bay and Garfield Bight (generally closer to shoreline stations in areas where crocodiles could occur) are used as input to HSI. Each day between August 1 through December 31 is assigned a score based on the following salinity ranges: salinity <20 psu was assigned the highest score of 1 because salinity in this range is considered most favorable for juvenile crocodile growth and survival (Moler 1992; Mazzotti 1999; Mazzotti et al. 2007); salinity $\geq$ 20 and <30 psu was assigned a score of 0.6; $\geq$30 and <40 psu was assigned a score of 0.3, and >40 psu a score of 0. Average yearly and an average overall score were calculated.

Results from applying the salinity data into the juvenile crocodile HSI is shown in **Figure C.2.1-43.** The plot shows the lift (Alternative minus FWO) of an index of juvenile crocodile growth and survival at sites along the northern Florida Bay shoreline for all years of the model runs. Sites in the orange box historically have had the most crocodile nesting. For the four sites with the highest predicted growth and survival, Alt 4 appears to perform better than the other alternatives. However, the difference in performance between alternatives is very subtle. For example, the maximum difference between Alt 4 and Alt 2 occurred in Terrapin Bay and is only about 0.02 units of the 0-1 scale index. Also, determination of any statistical significance between action alternatives is not possible. Not

surprisingly, the ranking of action alternatives follows the salinity performance measure ranking (Alt 4>Alt 3>Alt 1>Alt 2) because salinity is the only driver for HSI. Note that for the three locations that have the lowest crocodile HSI performance, there is almost no difference between alternatives, with Alts 3 and 4 performing nearly identically.

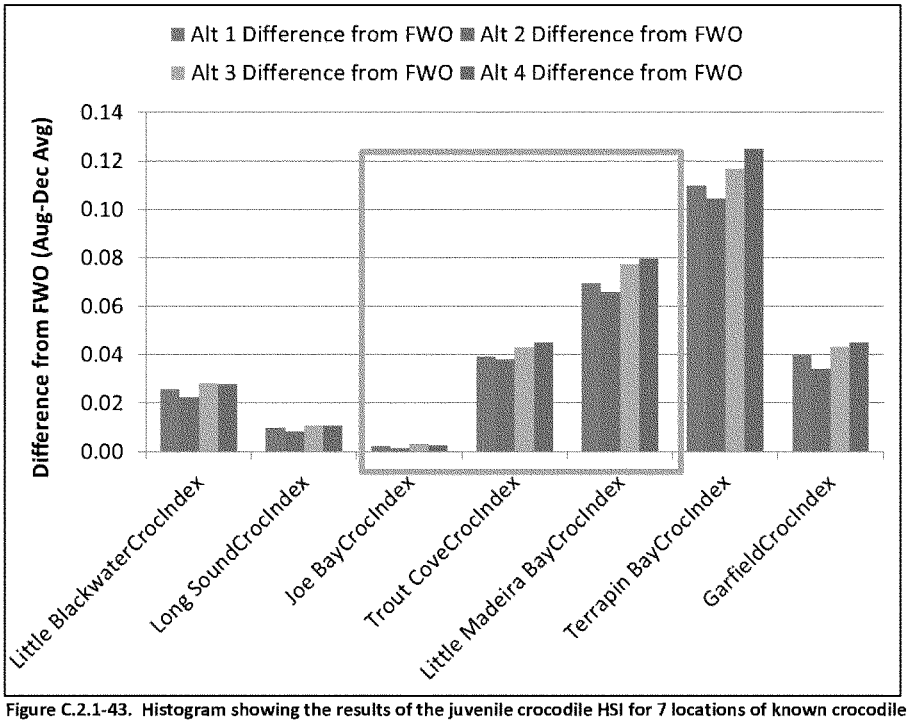


Figure C.2.1-43. Histogram showing the results of the juvenile crocodile HSI for 7 locations of known crocodile nesting areas. Index values show lift provided by action alternatives compared to FWO. (Brandt 2013)

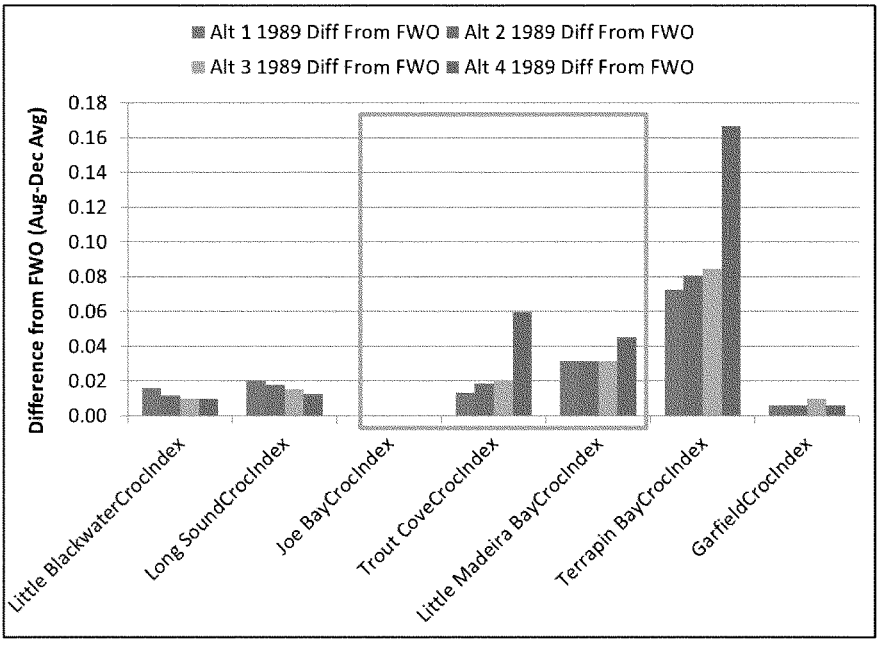


Figure C.2.1-44. Histogram showing the results of the juvenile crocodile HSI for 7 locations of known crocodile nesting areas during 1989 (very dry year). Index values show lift provided by action alternatives compared to FWO. (Brandt 2013)

Results of the juvenile crocodile HSI performance for an extremely dry (1989) year are shown in **Figure C.2.1-44**. For the three highest performing locations (Trout Cove, Little Madiera Bay, and Terrapin Bay), Alt 4 performed noticeably better than the other three alternatives. However, determination of any statistical significance between action alternatives is not possible. At sites with very low lift values (<0.02), differences between action alternatives was minimal (Brandt 2013). All action alternatives provide minor beneficial effects.

C.2.1.4.9 Smalltooth Sawfish

Implementation of the proposed project, the smalltooth sawfish may benefit from increased freshwater flows into the coastal wetlands adjoining Florida Bay, which would provide more natural and historic overland flows. All action alternatives have the potential to benefit the smalltooth sawfish by reducing excessive freshwater flows and improving the salinity regime throughout the Caloosahatchee estuary; and by increasing freshwater flows into the coastal wetlands adjoining Florida Bay, subsequently reducing the duration and occurrence of hypersaline conditions and provide minor beneficial effects.

Discharging large volumes of freshwater from Lake Okeechobee to the Caloosahatchee River during the wet season significantly reduces salinities and increases nutrient loading; all of which has a profound adverse effect on estuarine flora and fauna. As a result, the smalltooth sawfish may benefit from the

project's ability to reduce excessive freshwater flows by improving the salinity regime throughout the Caloosahatchee estuary.

C.2.1.4.10 Green Sea Turtle

The green sea turtle weighs approximately 150 kilograms and lives in tropical and sub-tropical waters. Areas that are known as important feeding areas for the green turtles in Florida include the Indian River Lagoon, the Florida Keys, Florida Bay, Homosassa, Crystal River and Cedar Key. Green turtles occupy three habitat types: high energy oceanic beaches, convergence zones in the pelagic habitat, and benthic feeding grounds in the relatively shallow, protected waters. Females deposit eggs on high energy beaches, usually on islands, where a deep nest cavity can be dug above the high water line. Hatchlings leave the beach and move in the open ocean. Green sea turtles forage in pastures of seagrasses and/or algae, but small green turtles can also be found over coral reefs, worm reefs, and rocky bottoms.

Although green sea turtles are expected to be found foraging in nearshore seagrass habitats within Florida Bay, the increased freshwater flows associated with all action alternatives may alter seagrass species composition but should have a negligible and less than significant effect on the overall biomass available for sea turtle feeding habits. Additionally, no green sea turtles would attempt to utilize areas for nesting purposes since there is no suitable habitat for nesting in the project area. With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea Turtle and Smalltooth Sawfish Construction Conditions, the Corps has determined green sea turtle may be affected, but is not likely to be adversely affected, by the proposed project.

C.2.1.4.11 Hawksbill Sea Turtle

The hawksbill sea turtle is a small to medium-sized marine turtle weighing up to 15 kilograms in the United States. The hawksbill lives in tropical and sub-tropical waters of the Atlantic, Pacific, and Indian Oceans. Areas that are known as important feeding areas for hawksbill turtles in Florida include the waters near the Florida Keys and on the reefs off Palm Beach County. Hawksbill turtles use different habitat types at different stages of their life cycle. Post hatchlings take shelter in weed lines that accumulate at convergence zones. Coral reefs are the foraging habitat of juveniles, sub-adults, and adults. They are also known to inhabit mangrove-fringed bays and estuaries, particularly along the eastern shore where coral reefs are absent. Hawksbills feed predominantly on sponges and nest on low and high energy beaches, frequently sharing 94 the high-energy beaches with green sea turtles. Nests are typically placed under vegetation.

Although hawksbill sea turtles are expected to be found foraging near hardbottom habitats within Florida Bay, the increased freshwater flows associated with all action alternatives may reduce nearshore salinity concentrations but should have a negligible and less than significant effect on sponges or other food sources utilized by this species. Additionally, no hawksbill sea turtles would attempt to utilize areas for nesting purposes since there is no suitable habitat for nesting in the project area. With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea Turtle and Smalltooth Sawfish Construction Conditions, the Corps has determined hawksbill sea turtle may be affected, but is not likely to be adversely affected, by the proposed project.

C.2.1.4.12 Leatherback Sea Turtle

The leatherback sea turtle is the largest living turtle and weighs up to 700 kilograms. The leatherback lives in tropical and sub-tropical waters. Habitat requirements for juvenile and post-hatchling leather-

backs are virtually unknown. Nesting females prefer high-energy beaches with deep unobstructed access. Leatherbacks feed primarily on jellyfish.

Although leatherback turtles are expected to be found foraging in nearshore habitats within Florida Bay, the increased freshwater flows associated with all action alternatives may reduce nearshore salinity concentrations but should have a negligible and less than significant effect on jellyfishes or other food sources utilized by this species. Additionally, no leatherback sea turtles would attempt to utilize areas for nesting purposes since there is no suitable habitat for nesting in the project area. With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea Turtle and Smalltooth Sawfish Construction Conditions, the Corps has determined leatherback sea turtle may be affected, but would not likely be adversely affected, by the proposed project.

C.2.1.4.13 Kemp's Ridley Sea Turtle

The Kemp's ridley sea turtle is the smallest of all sea turtles and weighs up to 45 kilograms. This species is a shallow water benthic feeder consuming mainly algae and crabs. Juveniles grow rapidly. Juveniles and sub-adults have been found along the eastern seaboard of the United States and in the Gulf of Mexico. However, the major nesting beach for the Kemp's ridley sea turtle is on the northeastern coast of Mexico. This species occurs mainly in coastal areas of the Gulf of Mexico and in the northwestern Atlantic Ocean. The post-pelagic stages are commonly found dwelling over crab-rich sandy or muddy bottoms. Juveniles frequent bays, coastal lagoons, and river mouths. 95

Although Kemp's ridley sea turtles could be found foraging in nearshore habitats within Florida Bay, this species is not expected to be found within the direct area of influence associated with CEPP. Additionally, no Kemp's ridley sea turtles would attempt to utilize areas for nesting purposes since their main nesting location is on a single stretch of beach on the Gulf Coast of Mexico. With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea Turtle and Smalltooth Sawfish Construction Conditions, the Corps has determined Kemp's ridley sea turtle may be affected, but would not likely be adversely affected, by the proposed project.

C.2.1.4.14 Loggerhead Sea Turtle

Loggerhead sea turtles inhabit the continental shelves and estuarine environments along the margins of the Atlantic, Pacific, and Indian Oceans. Females select high energy beaches on barrier strands adjacent to continental land masses for nesting. Steeply sloped beaches with gradually sloped offshore approaches are favored. After leaving the beach, hatchlings swim directly offshore and eventually are found along drift lines. They migrate to the near-shore and estuarine waters along the continental margins and utilize those areas as the developmental habitat for the sub-adult stage. Loggerheads are predators of benthic invertebrates.

Although loggerhead sea turtles are expected to be found foraging in nearshore habitats within Florida Bay, the increased freshwater flows associated with all action alternatives may reduce nearshore salinity concentrations but should have a negligible and less than significant effect on crustaceans, mollusks or other invertebrate food sources utilized by this species. Additionally, no loggerhead sea turtles would attempt to utilize areas for nesting purposes since there is no suitable habitat for nesting in the project area. With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea Turtle and Smalltooth Sawfish Construction

Conditions, the Corps has determined loggerhead sea turtle may be affected, but would not likely be adversely affected, by the proposed project.

C.2.1.4.15 State Listed Species

The CEPP project area contains habitat suitable for the presence, nesting, and/or foraging of 16 state-listed threatened and endangered species and 18 species of special concern. Threatened and endangered animal species include the Big Cypress fox squirrel (*Sciurus niger avicennia*), Florida mastiff bat (*Eumops glaucinus floridanus*), Florida black bear (*ursus americanus floridanus*), Everglades mink (*Mustela vison evergladensis*), Florida sandhill crane (*Grus canadensis pratensis*), snowy plover (*Charadrius alexandrius*), Southeastern American kestrel (*Falco sparveriuspaulus*), least tern (*Sterna antillarum*), white-crowned pigeon (*Columba leucocephalus*), and Miami black-headed snake (*Tantilla oolitica*). Species of special concern include the Florida mouse (*Podomys floridanus*), Shermans fox squirrel (*Sciurus niger shermani*), American oystercatcher (*Haematopus palliates*), brown pelican (*Pelecanus occidentalis*), black skimmer (*Rynchops niger*), burrowing owl (*Athene cunicularia*), limpkin (*Aramus guarauna*), reddish egret (*Egretta rufescens*), snowy egret (*Egretta thula*), little blue heron (*Egretta caerulea*), tricolored heron (*Egretta tricolor*), white ibis (*Eudocimus albus*), roseate spoonbill (*Platalea ajaja*), osprey (*Pandion haliaetus*), mangrove rivulus (*Kryptolebias marmoratus*), mangrove gambusia (*Gambusia rhizophorae*), gopher tortoise (*Gopherus polyphemus*), and the Florida tree snail (*Liguus fasciatus*).

Threatened and endangered plant species include the pine-pink orchid (*Bletia purpurea*), which frequents the edges of the farm roads just above wetland elevation; the lattice-vein fern (*Thelypteris reticulate*) which is found (*Anemia wrightii*) both found in the Frog Pond natural area; along with the Mexican vanilla plant (*Vanilla mexicana*) and Schizaea tropical fern (*Schizaea pennula*) located on tree islands in the upper Southern Glades region.

While small foraging or nesting areas utilized by many of these animal species may be affected by this project, Alts1-4 are not likely to adversely affect protected state species. Impacts to wading birds species will be similar to those affecting the wood stork. Overall, negligible and less than significant adverse impacts are anticipated to state listed species as a result of this project.

C.2.1.5 Fish and Wildlife Resources

A comparison of FWO and CEPP action alternatives and their potential effects on wildlife within the CEPP action area are summarized below. Effects to state and federally listed species are described in further detail in **Section C.2.1.4, Threatened and Endangered Species** and within **Annex A**. Changes in water quality also have the potential to affect prey forage base through altering of vegetation composition or structure. Implementation of CEPP action alternatives would significantly benefit fish and wildlife resources within the CEPP action area, particularly within the greater Everglades. These benefits are described in greater detail in the sections below. Water quality will continue to be monitored under CEPP; potential effects are largely uncertain at this time.

C.2.1.5.1 Invertebrates

Negligible and less than significant effects to the invertebrate community within Lake Okeechobee or EAA are anticipated under any CEPP action alternative. As compared with FWO, all CEPP action alternatives show a minor beneficial effect with performance improvement within the Northern Estuaries as indicated by fewer high volume flow months. Reductions in high volume discharges and salinity fluctuations would likely benefit oysters within the Northern Estuaries. Reduction in high flows and accompanying flow velocities would help lessen the current problem of flushing of oyster spat into

outer areas of the Northern Estuaries that experience high salinities levels during the dry season resulting in increased predation and disease in the oyster population. In the St. Lucie Estuary a minor adverse effect is expected due to increases in low flow violations during the dry season were indicated by the modeling effort. Recent oyster monitoring data during extended dry conditions in the area has shown an increase in oyster disease related to the duration and severity of high salinity conditions. Although these extreme dry spells are rare in the SLE, they can occur and therefore supplemental flows during dry times may be warranted and have been accounted for in the IRLS water reservation process. Delivery of those supplemental flows should ideally take place through the North Fork St. Lucie River.

Within the Greater Everglades aquatic invertebrates would rapidly colonize newly re-hydrated areas with implementation of any CEPP action alternative providing a moderate and significant beneficial effect, directly benefitting aquatic invertebrates within the action area. Increases in stages and hydroperiods within WCA 2, northern WCA 3A, WCA 3B and ENP would promote wetland vegetation transition through contraction of sawgrass marshes and expansion of wet prairies, and in deeper regions, sloughs. Submerged aquatic plants are commonly associated with sloughs providing structure for growth of periphyton, the main source of primary production within the freshwater Everglades (Gunderson 1994; Powers 2005).

Periphyton is a primary component of invertebrate diets, including apple snails. In addition to the potential for increased foraging opportunities, changes in vegetation resulting in expansion of wet prairie and increases in emergent vegetation would also provide habitat structure critical for apple snail aerial respiration and egg deposition (Turner 1996; Darby et al. 1999). Apple snails tend to avoid areas where water depths are greater than 50 centimeters (Darby et al. 2002). Avoidance of deeper depths may be related to the type and density of vegetation in deeper water areas, food availability or energy requirements for aerial respiration (van der Walk et al. 1994; Turner 1996; Darby 1998; Darby et al. 2002). Water-lily sloughs support lower apple snail densities as compared with wet prairies (Karunaratne et al. 2006). Limited food quality and lack of emergent vegetation in sloughs may account for the lower densities. Research indicates that apple snails depend upon periphyton for food (Rich 1990; Browder et al. 1994; Sharfstein and Steinman 2001), which may be limited within deeper water environments. Karunaratne et al. (2006) observed little or no submerged macrophytes and epiphytic periphyton in the sloughs they studied in WCA 3A. In contrast, species commonly encountered within wet prairie habitat (e.g. *Eleocharis* spp., *Rhynchospora tracyi*, *Sagittaria* spp.), along with sawgrass that grows within the ecotones between the two vegetative communities, support abundant populations of epiphytic periphyton (Wetzel 1983; Browder et al. 1994; Karunaratne et al. 2006). A reduction in the number of available emergent stems for egg deposition would also contribute to the observed lower snail densities within sloughs. Drying events are needed to maintain the emergent plant species characteristic of typical apple snail (Wood and Tanner 1990; Davis et al. 1994). As shown by Darby et al. (2008), apple snails can survive these events and it is the timing and duration of the dry down event that are critical determinants of apple snail survival and recruitment. All CEPP action alternatives provide increased opportunities for apple snails within northern WCA 3A; while Alts 3 and 4 provide greater potential for providing appropriate conditions for increased apple snail populations in ENP as compared with Alts 1 and 2 and a minor beneficial effect.

Crayfish are important components within the Everglades food web, serving as primary dietary components of higher trophic level species including fish, amphibians, alligators, wading birds and mammals such as raccoons and river otters (Kushlan and Kushlan 1979). Crayfish are particularly important forage resource for nesting white ibis (*Eudocimus albus*), therefore the availability of crayfish is an important component for recovery of this species. Crayfish species composition and abundance

within the Greater Everglades are linked to hydroperiod. Two species of freshwater crayfish are found within the Greater Everglades: Everglades crayfish (*Procambarus alleni*) and slough crayfish (*Procambarus fallax)*. Everglades crayfish is commonly found in marshes that dry seasonally, generally with a hydroperiod of less than 10 months. When surface water recedes, the Everglades crayfish burrows to escape drying conditions. The slough crayfish is commonly found in perennially flooded habitats. Both species have been found co-occurring in areas with hydroperiods ranging between 9 and 11 months, as well as in sites that remained flooded during the dry season.

Increases in hydroperiod associated with implementation of any CEPP action alternative would likely increase crayfish density with northern WCA 3A, WCA 3B and ENP, particularly within the marl prairies and provide a minor and significant beneficial benefit. Research by Acosta and Perry (2001) revealed that environmental changes associated with shortened hydroperiod have affected growth, survival, dispersal and productivity within Everglades marl prairies and within the rocky glades. Results from this study indicate that crayfish productivity would increase substantially if hydroperiods within marl prairies wetlands were extended by 3 to 4 months. Although none of the CEPP action alternatives would extend hydroperiods within marl prairies by this duration, all CEPP action alternatives, especially Alts 4 and 3 would increase hydroperiods within this region resulting in increased Everglades crayfish productivity.

Everglades crayfish biomass also declines during periods of extended high water. During extended periods of inundation, populations of large predatory fish species may increase, thereby increasing predation pressure on crayfish populations (Kushlan and Kushlan 1979). Under CEPP, areas in which hydroperiods will be extended sufficiently to support increases in large predatory fish (refer to **C.2.1.5.2**), there will likely be associated declines in Everglades crayfish biomass. In contrast, areas within southern WCA 3A that currently endure deeper water depths and extended hydroperiods due to ponding, may experience increases in Everglades crayfish biomass due to reduction in water depth and hydroperiods with implementation of any CEPP action alternative.

Within Florida Bay, a habitat suitability index model was employed to simulate growth, survival and potential harvest of a cohort of shrimp as a function of salinity and temperature (Browder et al. 1999; 2002). Results of the 41-year POR simulations of potential harvests from two representative Florida Bay basins, Whipray Basin in north central Florida Bay and Johnson Key Basin in western Florida Bay, are shown in **Figure C.2.1-45** and **Figure C.2.1-46**, respectively. Results show the lift above FWO (as percent of FWO) in potential harvests from each of the four action alternatives providing a minor beneficial effect. The equation for calculating lift as percent of FWO follows: $100 \times (ALT_x - FWO) / FWO$, where ALT_x is simulated potential harvest from a given alternative and FWO is simulated potential harvest from FWO salinity conditions. Each alternative provides substantial lift in potential harvest over FWO. The lift in each case is a small percentage of FWO (i.e., 1.05%, at most). In both areas, the lift provided by Alt 4 is greater than that of the other three action alternatives. Alternative 1 provides the least lift. Variation across alternatives in most years is less than inter-annual variation. (RECOVER 2013, **Annex E**).

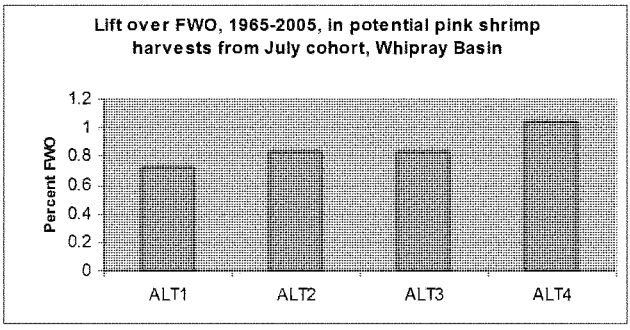


Figure C.2.1-45. Histogram showing the results of the potential pink shrimp harvest in Whipray Basin for the 1965-2005 period of record for model output.

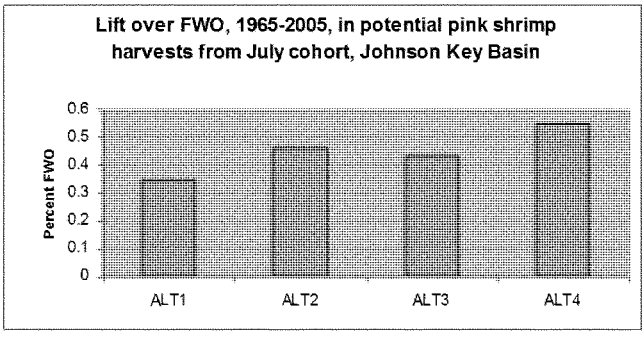


Figure C.2.1-46. Histogram showing the results of the potential pink shrimp harvest in Johnson Key Basin for the 1965-2005 period of record for model output.

In Biscayne Bay, Alt 2 was the only alternative that provided additional flows when compared to FWO and a minor beneficial effect. Alts 1, 3, and 4 all provided less water than FWO, in descending order and a minor adverse effect. Flows to the coast were not evenly distributed spatially with all alternatives showing positive benefits in the northern Biscayne Bay and negative effects in central and southern Biscayne Bay. Alternative 2 is likely to provide a benefit to the invertebrate population by providing additional flows to the coast, thereby lowering salinity levels and/or reducing the number of days salinities exceed 40 psu. Alternative 1 is likely to provide the same level of benefit as FWO and Alts 3 and 4 would likely result in a negative effect to the invertebrate population by increasing the likely hood of maintaining salinity conditions in Biscayne Bay above the preferred salinity range of the resident invertebrate population for longer periods of time than FWO. All alternatives generally show an unfavorable seasonal flow pattern with reductions in flows compared to FWO generally greater during the dry season. Refer to Annex E for Biscayne Bay Flow at Coastal Structures.

C.2.1.5.2 Fish

Implementation of any CEPP action alternative is expected to significantly improve conditions for fish species throughout much of the Greater Everglades and have a moderate and significant beneficial effect. The largest percent gains in daily average fish density were predicted within northern WCA 3A and NESRS. In these areas fish densities increased in excess of 30%, with extremes over 80%. Other areas within SRS also experienced appreciable gains in fish density due to increased flows. In comparison, all CEPP action alternatives resulted in lower fish densities within WCA 3A along L-67A. Regional percent changes in fish densities were highest in SRS (16-23%) and southern marl prairies (17-31%) as compared with FWO, with Alts 3 and 4 exhibiting the largest percent increases. Taylor Slough experienced negligible positive changes (<1%). (Catano and Trexler 2013, **Annex E**).

Introduction or expansion of non-native fish species due to changes in water distribution and increased connectivity within WCA 3A, WCA 3B and ENP is likely to occur; however, the extent of invasion is uncertain at this time providing a minor adverse effect. In contrast to FWO, new access points will be created under all CEPP action alternatives, with the highest connectivity achieved under Alts 3 and 4. Alternative 1 would provide the fewest number of new access points, thus limiting the potential for spread of invasive and or exotic fish species as compared with the other action alternatives.

Within Florida Bay, a habitat suitability index (HSI) was employed to predict responses of juvenile spotted seatrout (*Cynoscion nebulosus*) with implementation of any CEPP alternative and predict improvements in habitat suitability in comparison with FWO. The spotted seatrout HSI is a qualitative model that uses a logistic regression to assess how the frequency of occurrence of juvenile spotted seatrout varies in response to environmental parameters including turbidity, temperature, salinity, and spatial coverage and density of three species of seagrass (RECOVER 2013, **Annex E**). The model calculates the area of habitat suitable for juvenile spotted seatrout based on the above parameters. For this analysis, all parameters were held constant except for salinity. For juvenile spotted seatrout, there are five biologically relevant ranges for salinity as determined by the linear response in cumulative frequency of seatrout to salinity. HSI index scores were then calculated by taking the frequency of occurrence for each of these five ranges and dividing by the highest frequency of occurrence for any of the ranges. For example, the range from a salinity of 32 to 39 had the highest frequency of occurrence at 0.255 and received an SI=1 (0.255/0.255); however, the range from a salinity of 40 to 52 had a frequency of occurrence of 0.145 and an SI=0.57 (0.145/0.255).

The juvenile spotted seatrout HSI was run on monthly average salinities from May through November to coincide with spotted seatrout juvenile recruitment for all CEPP action alternatives. The HSI output from the salinity monitoring stations in Florida Bay was gridded to produce spatial distributions of HSI scores for each month. This allowed for the calculation of area of optimal juvenile spotted seatrout habitat in square kilometers. The mean area of optimal juvenile spotted seatrout for each scenario for the entire POR is shown in **Figure C.2.1-47.** The error bars reflect the standard error for the data set. The natural system model serves as the target for this analysis. It had the largest mean area of optimal juvenile spotted seatrout habitat at 368 km^2. All four CEPP action alternatives showed improvements over FWO providing a minor beneficial effect. A Mann-Whitney U-test was applied to conduct pair-wise comparisons among all of the scenarios. All four CEPP action alternatives had significantly higher areal extent of optimal habitat for juvenile spotted seatrout (α=0.1) compared to FWO. However, there were no significant differences among any of the action alternatives (α=0.1). (RECOVER 2013, **Annex E**)

To ease in the interpretation of the spotted seatrout data, the percent increase in area of optimal juvenile spotted seatrout relative to FWO is depicted in **Figure C.2.1-48**. The four CEPP action

alternatives showed increases from 44% for Alt 1 up to 65% for Alt 4. Alternatives 2 and 3 showed a 49% and 52% increase, respectively. The juvenile spotted seatrout analysis shows that all CEPP action alternatives showed statistically significant improvement over FWO. The differences among the alternatives were not statistically significant, but suggest Alt 4 has the highest potential to show the greatest gains for spotted seatrout in Florida Bay.

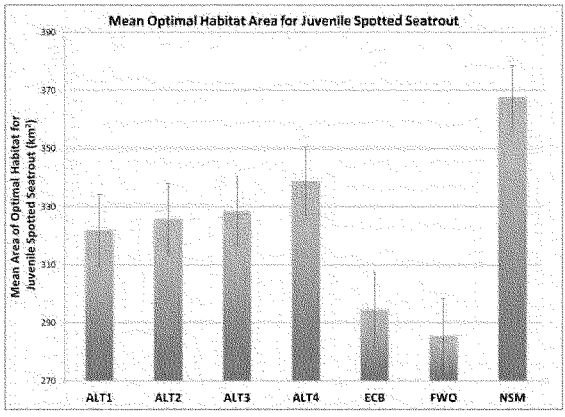


Figure C.2.1-47. Histogram showing the mean optimal habitat area of the juvenile spotted seatrout HSI for NSM (target), ECB, FWO and the four CEPP action alternatives. (RECOVER 2013, Annex E)

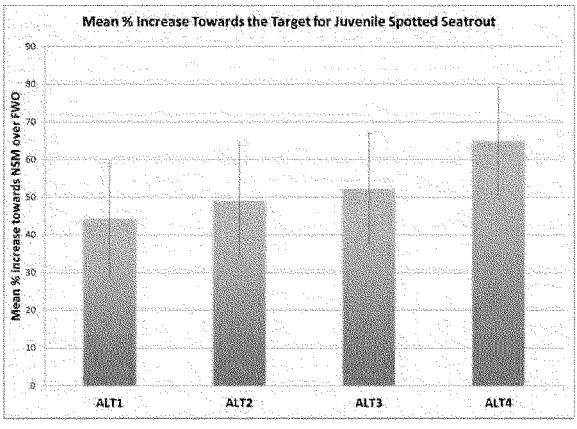


Figure C.2.1-48. Histogram showing the mean increase towards the target for the juvenile spotted seatrout HSI for the four CEPP action alternatives relative to FWO. (RECOVER 2013, Annex E)

In Biscayne Bay, Alt2 was the only alternative that provided additional flows when compared to FWO and minor beneficial effect. Alts 1, 3, and 4 all provided less water than FWO, in descending order and a minor adverse effect. Flows to the coast were not evenly distributed spatially with all alternatives showing positive benefits in the northern Biscayne Bay and negative effects in central and southern

Biscayne Bay. Alternative 2 is likely to provide a benefit to the fish population by providing additional flows to the coast, thereby lowering salinity levels and/or reducing the number of days salinities exceed 40 psu. Alternative 1 is likely to provide the same level of benefit as FWO and Alts 3 and 4 would likely result in a negative effect to the fish population by increasing the likely hood of maintaining salinity conditions in Biscayne Bay above the preferred salinity range of the resident fish population for longer periods of time than FWO. All alternatives generally show an unfavorable seasonal flow pattern with reductions in flows compared to FWO generally greater during the dry season. Refer to Annex E for Biscayne Bay Flow at Coastal Structures.

C.2.1.5.3 Amphibians and Reptiles

Minor beneficial effects to amphibian and reptile communities are anticipated under all CEPP action alternatives. All action alternatives showed improved conditions for amphibians within WCA 3 and ENP as compared with FWO. Rehydration within previously dry areas within northern WCA 3A would increase spatial extent of suitable habitat for aquatic amphibian species in this area. Similarly, increased hydroperiods within ENP would also benefit aquatic amphibian species. As hydrology improves within WCA 3 and ENP it is expected that amphibian species richness will also change. However, declines in some amphibian species will be offset by favorable habitat conditions for other species. Increase in forage prey availability (i.e. crayfish and other invertebrates, fish) in areas rehydrated by CEPP implementation will also directly benefit amphibian and reptiles species.

Introduction or expansion of non-native amphibian species due to changes in water distribution and increased connectivity within WCA 3A, WCA 3B and ENP is likely to occur; however, the extent of invasion is uncertain at this time and may have a minor adverse effect. In contrast to FWO, new access points will be created under all CEPP action alternatives, with the highest connectivity achieved under Alts 3 and 4. Alternative 1 would provide the fewest number of new access points, thus limiting the potential for spread of invasive and or exotic amphibian species as compared with the other action alternatives.

Submerged aquatic vegetation and algal communities are also common foraging areas for the green sea turtle. Reductions in high and low flow violations within the Northern Estuaries reduce stress on SAV and promote increases in seagrass shoots that have the potential to increase foraging opportunities for green sea turtles in this region. Similarly, increased freshwater flows to Florida Bay and the southwestern coastal estuaries resulting in lowered salinity levels that better encompass seagrass salinity tolerance ranges, would also increase foraging opportunities for green sea turtles. Alternative 4 provides the greatest benefit, followed by Alts 3, 1 and 2 (refer to **C.2.1.3.5.2, Seagrass Beds** for further information).

C.2.1.5.4 Birds

The freshwater wetlands of the Everglades are noted for their abundance and diversity of colonial wading birds. Nesting and foraging activities of resident bird species are anticipated to show a moderate beneficial effect with implementation of any CEPP action alternative. Impacts to the CSSS, snail kite, wood stork and wading birds are further discussed in **Section C.2.1.4, Threatened and Endangered Species** and within **Annex A**. Changes in water quality also have the potential to affect birds through alteration of vegetation composition or structure or impacts to their forage base. Water quality would continue to be monitored under CEPP and potential effects are largely uncertain at this time.

As predicted by the Trophic Hypothesis (RECOVER 2004) an increase in density of small fishes would directly benefit higher trophic level predators such as wading birds. Therefore, it is predicted that the action alternatives that provide the greatest benefit to small fishes as described in **Section C.2.1.5.2,**

Fish, would also perform best overall for wading birds. Crayfish are a particularly important forage resource for nesting white ibis (*Eudocimus albus*). Appropriate foraging conditions and crayfish densities within core foraging areas of nesting wading birds colonies can reduce foraging flight distance, thereby enhancing overall body condition. As indicated in **Section C.2.1.5.1, Invertebrates**, increases in hydroperiod associated with implementation of any of the CEPP action alternatives would likely increase crayfish density within northern WCA 3A, WCA 3B and ENP, particularly within the marl prairies.

The largest wading bird rookery within the Everglades ecosystem is Alley North. Under current and FWO conditions, a large dry area within northeastern WCA 3A creates a significant hazard for nesting birds due to egg predation by mammals. All CEPP action alternatives show significant hydrological improvement within northeastern WCA 3A. Associated increased depths, hydroperiods and sheetflow with Alley North decrease the potential for nest predation and provide a minor beneficial effect.

As compared with FWO, all CEPP action alternatives reveal the potential for short-term minor adverse effects to aquatic vegetation within Lake Okeechobee due to higher than preferred lake stages. As a result, temporary reductions in foraging habitat for shorebirds and short-legged wading birds could occur. However, these multiple day events in which Lake Okeechobee stage exceeded 15.0 feet NGVD occurred approximately 5% of the POR.

C.2.1.5.5 Mammals

As compared with FWO, potential minor beneficial effects to mammals within the CEPP action area are anticipated with implementation of any CEPP action alternative. Small mammals including raccoons and river otters would benefit from increased crayfish and small prey fish biomass in rehydrated areas within northern WCA 3A, WCA 3B, and ENP. Effects to state and federally listed species are described in further detail in **Section C.2.1.5, Threatened and Endangered Species** and within **Annex A**. Changes in water quality also have the potential to affect prey forage base through altering of vegetation composition or structure. Water quality would continue to be monitored under CEPP; potential effects are largely uncertain at this time. However, it is predicted that restoration of sheetflow will aid to remove nutrients within the water column.

CEPP implementation, however, could have a significant and adverse effect on mammals dependent upon upland habitat. Due to increased water flow and changes in water distribution it is anticipated that overdrained areas in northern WCA 3A would be rehydrated, triggering a vegetation transition from upland to wetland habitat. Although, mammals occurring within the action area are adapted to the naturally fluctuating water levels in the Everglades; there is an increased potential for this vegetation transition to negatively affect mammals utilizing upland habitat. This is a particular concern for deer populations within northern WCA 3A that utilize tree islands. However, as discussed in **Section C.2.1.4.4, Tree Islands**, no significant effects to tree islands within WCA 3A and ENP are anticipated to occur under any CEPP action alternative; but, lower elevation tree islands within WCA 3B may be adversely affected by CEPP implementation, with Alts 2 and 3 resulting in the greatest potential impact. Deer populations that utilize the lower elevation tree islands within WCA 3B may suffer from habitat loss. In addition, deer that utilize levees slated for removal (L-67C, L-29, L-67 Extension) also have the potential to be negatively affected. Loss of these levees may be offset by the construction of the Blue Shanty Levee in WCA 3B. Deer are highly mobile and would migrate to find suitable habitat. No significant negative effects on mammals in the remainder of the CEPP action area are anticipated under any CEPP action alternative.

C.2.1.6 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act, 16USC 1801 et seq. Public Law 104-208 reflects the Secretary of Commerce and Fishery Management Council authority and responsibilities for the protection of essential fish habitat (EFH). Federal agencies that fund, permit, or carry out activities that may adversely impact EFH are required to consult with the National Marine Fisheries Service (NMFS) regarding the potential effects of their actions on EFH. In conformance with the 1996 amendment to the Act, the information provided in this Integrated Environmental Impact Statement (EIS) will comprise the required EFH assessment and has been coordinated with NMFS.

Consultation for the Central Everglades Planning project (CEPP) was initiated on January 10, 2012 through a NEPA scoping letter. The NMFS has indicated that beneficial effects to fish resources and EFH may occur as a result of this project. The NMFS requested an evaluation of potential impacts to living marine resources, including mangroves, seagrasses, live bottom communities, and the marine/estuarine water column that may be impacted by activities or operations of the project action alternatives. The preparation of an EFH assessment will be contained within the project PIR/EIS, and submitted to the NMFS for coordination.

Essential Fish Habitat in the Project Area:

The project area includes three distinct regional estuarine and nearshore coastal systems: The southern estuaries including Biscayne Bay and Florida Bay; and the northern estuaries including the Caloosahatchee River and the St. Lucie Estuary.

The southern estuaries comprise Biscayne National Park and a large portion of Everglades National Park, and are a shallow estuarine system (average depth less than 3 feet). Florida Bay is the main receiving water of the greater Everglades, heavily influenced by changes in timing, distribution, and quantity of freshwater flows into the southern estuaries. Lake Okeechobee discharges into the two northern estuaries. The St. Lucie Canal feeds into the St. Lucie Estuary, and the Caloosahatchee Canal/River feeds into the Caloosahatchee Estuary to the west.

Biscayne Bay and Florida Bay

The southern estuaries contain essential fish habitat for corals; coral reef and live bottom habitat; red drum (*Sciaenops ocellatus*); penaeid shrimps; spiny lobster (*Panulirus argus*); other coastal migratory pelagic species and the snapper-grouper complex. Species generally present in the southern estuaries region include brown shrimp (*Penaeus aztecus*), pink shrimp (*Penaeus duorarum*), white shrimp, spiny lobster, stone crab, gulf stone crab, red drum, Spanish mackerel, and gray snapper (*Lutjanus griseus*). Essential fish habitat in the southern estuaries is comprised of seagrasses, estuarine mangroves, intertidal flats, the estuarine water column, live/hard bottoms, and coral reefs.

Caloosahatchee River

The Caloosahatchee River estuary contains essential fish habitat for juvenile brown shrimp (*Penaeus aztecus*), juvenile gray snapper (*Lutjanus griseus*), juvenile pink shrimp (*Penaeus duorarum*), adult and juvenile red drum, (*Sciaenops ocellatus*), adult and juvenile Spanish mackerel (*Scomberomorus maculatus*), and juvenile stone crab (*Menippe mercenaria*). Downstream habitats include oyster reefs and seagrass beds (submerged aquatic vegetation).

St. Lucie Estuary

The proposed project is within the jurisdiction of the South Atlantic Fishery Management Council (SAFMC) and is located in areas designated as EFH for wormrock, live bottom habitat, for the American

oyster (*Crassostrea virginica*); pink shrimp (*Penaeus duorarum*); white shrimp (*Penaeus* sp.) and brown shrimp (*Penaeus aztecus*); Florida red drum (*Sciaenops ocellatus*); grouper (*Epinephelus* spp.); gray snapper (*Lutjanus griseus*); white grunt (*Haemulon plumieri*); red porgy (*Pagrus pagrus*); spiny lobster (*Panulirus argus*); and the snapper-grouper complex. In addition, the nearshore hardbottom habitat outside of the St. Lucie Estuary is designated as Essential Fish Habitat-Habitat Areas of Special Concern (EFH-HAPC) for the snapper-grouper complex.

Assessments of Effects on Essential Fish Habitat:

Southern Estuaries

Project construction activities should have no effect on the nearshore communities or essential fish habitat downstream of the project areas in Biscayne Bay and Florida Bay. However, this project is expected to have a minor beneficial indirect effect by increasing overland flow into Eastern Florida Bay. The increased flow is anticipated to stabilize the water quality and salinities required to improve and sustain nearshore biological communities.

Seagrasses are expected to benefit from the re-direction and dispersion of fresh water across the wetland systems prior to entering Biscayne Bay and Florida Bay. Seagrass habitats are heavily utilized by both juvenile and adult fishes and invertebrates for feeding and shelter (SAFM 1998). Species that depend on seagrass habitats include the penaeid pink and brown shrimp, and spiny lobster (SAFM 1998). Seagrass performs as an important nursery habitat for red drum, snook (*Centropomus undecimalis*), bonefish (*Albula vulpes*), tarpon (*Megalops atlanticus*) and several species of snapper and grouper, and is critical to the health of Biscayne Bay, Florida Bay, and a number of commercial and recreational fisheries (SAFM 1998).

The restored hydrology provided by this project would also increase the periodic inundation of the downstream mangrove wetlands. Mangrove wetlands depend on this periodic inundation; the lack of freshwater from upstream sources contributes to their degradation (SAFM 1998). Mangrove habitats are important because they provide food and refuge to a large variety of species. These species include: spiny lobsters, pink shrimp, snook (*Centropomus undecimalis*), goliath grouper (*Epinephelus itajara*), tripletail (*Lobotes surinamensis*), leatherjack (*Oligoplites saurus*), gray snapper (*Lutjanus griseus*), dog snapper (*L. jocu*), sailor's choice (*Haemulon parra*), bluestriped grunt (*H. sciurus*), sheepshead (*Archosargus probatocephalus*), black drum (*Pogonias cromis*) and red drum (SAFM 1998).

The estuarine water column is typically characterized by four salinity categories: oligohaline (< 8 psu), mesohaline (8-18 psu), and polyhaline waters (18-30 psu) with some euhaline water (>30 psu) around inlets (SAFM 1998). Saline boundaries in the estuarine water column are variable, but are generally maintained by sea water transported through inlets by tide and wind mixing with fresh water supplied by land runoff' (SAFM 1998). This project will improve quantity, timing, and distribution of water delivered to Eastern Florida Bay. It is likely that this will result in an improvement to the salinity characteristics of the estuarine water column. This habitat is utilized by larvae of commercially important fishes for feeding, and is an important means of conveying organisms and nutrients from inland to offshore areas (SAFM 1998).

This project is not expected to have an effect on coral reef or hard bottom communities in the southern estuaries. There are no coral reefs or hard bottom communities located within the proposed project site or the nearshore waters affected by the project. Corals found within Florida Bay and Biscayne Bay are outside the area of potential effect.

Northern Estuaries

Aquatic habitats within the Caloosahatchee Basin have been altered through the channelization of the river. Nevertheless, the basin continues to support fishery resources of some recreational and commercial importance. Seagrass communities within the Caloosahatchee estuary provide critical refugia for juvenile fishes such as redfish, grouper, snook, and spotted seatrout. The decline in juvenile abundance and distribution of these and other species, along with an overall decrease in species richness may be related to the loss of seagrass habitat and/or a result of alterations in the salinity regime and the timing of the freshwater discharges from the S-79 structure. Implementation of the project would reduce the frequency of high volume freshwater discharges during the wet season, ultimately resulting in minor beneficial effects to essential fish habitat within the Caloosahatchee estuary.

Another primary goal of this project is to reduce high nutrient freshwater flows to the St. Lucie estuary. No direct impacts are anticipated, rather the restoration potential of seagrass beds, oyster reef, and the estuarine water column itself. Increases in seagrass and oyster reef would provide a large number of benefits to the essential fish habitat species. The proposed project significantly increases the acres of SAV, oyster, and healthy benthic habitat.

Conclusion:

Southern Estuaries

Previous water management operations have resulted in an inland migration of saline conditions in both groundwater and surface waters. This has caused the expansion of moderate to high salinity zones and has diminished the spatial extent of freshwater wetland habitats in the southern estuaries. Landward expansion of saltwater and mangrove wetlands, including low-productivity, sparsely vegetated dwarf mangrove communities typical of the hypersaline 'white zone' has also occurred in the southern estuaries.

The proposed project components would improve freshwater delivery to coastal wetlands and adjacent estuaries in Northern Biscayne Bay and Eastern Florida Bay. Implementation of the project would redistribute flow to salt water wetlands and nearshore bay areas and result in favorable changes to salinity levels. These changes may affect essential fish habitat, although the impacts to the aquatic resources are anticipated to be significant and beneficial.

Northern Estuaries

The Caloosahatchee and St. Lucie estuaries both receive excessive discharges from Lake Okeechobee as well as their local basins during wet years, and suffer from too little discharge on excessively dry years.

Restoration goals in the Caloosahatchee estuary include; re-establishment of a salinity range favorable to juvenile marine fish, shellfish, oysters and submerged aquatic vegetation (SAV), re-establishment of seasonally appropriate freshwater flows of favorable quality that maintain low salinities in the upper estuary and re-establishment of more stable salinities and ranges in the lower estuary. Restoration goals for the St. Lucie estuary include maintaining a salinity range favorable to fish, benthic invertebrates, oysters and SAV. This requires a reduction of high volume, long duration discharge events from Lake Okeechobee, the C-44, C-23 and C-24 watersheds.

In summary, CEPP may improve conditions for estuarine and marine resources throughout the Northern Estuaries by restoring more natural timing, volume, and duration of freshwater flows to the Caloosahatchee and St. Lucie estuaries and provide minor beneficial effects. It has the potential to

reduce excess nutrient loading and provide a more appropriate range of salinity conditions by reducing extreme salinity fluctuations and durations. The improvement of estuarine conditions will ultimately have a significant beneficial effect to essential fish habitat resources.

C.2.1.7 Hydrology

Hydrologic modeling simulations of the existing condition baseline (ECB) and the CEPP future without project condition (FWO) were developed with the RSM-BN and RSM-GL sub-regional modeling tools, to provide baseline conditions for plan formulation, the assessment of CEPP project benefits (comparisons against FWO), and the assessment of CEPP alternative performance for the level-of-service for flood protection and water supply (comparisons against ECB). The ECB was developed to represent the system-wide infrastructure and operations that were in place at the time CEPP plan formulation was initiated, approximately January 2012. The FWO for CEPP assumes the construction and implementation of currently authorized CERP and non-CERP projects, and other Federal, state or local projects constructed or approved under existing governmental authorities that occur in the CEPP study area. Selection of the TSP is conducted based on comparisons between the CEPP action alternatives and the CEPP FWO. The reader should refer to Section 2 of the CEPP PIR main report and Appendix C.1 for additional documentation of the ECB and FWO conditions.

The portion of the Greater Everglades within the CEPP project area includes WCA 1, WCA 2A, WCA 2B, WCA 3A, WCA 3B, and ENP. This overview of CEPP hydrological conditions is intended to provide a general overview of regional hydrological changes for the CEPP action alternatives compared to the CEPP FWO. RSM-BN and RSM-GL hydrologic modeling simulations for the CEPP final array of action alternatives were developed starting from the FWO modeling simulations. Since all of the components north of the red line are the same for the CEPP preliminary final array of action alternatives (Alts 1 through 4), a single RSM-BN simulation for Lake Okeechobee, the northern estuaries, and the EAA was completed to represent all of the action alternatives and provide boundary conditions to the RSM-GL modeling. Hydrologic performance within any specific spatial area is due to the combined effect of CEPP alternative components and operations identified throughout the project area. Deduction of cause-effect relationships between CEPP alternative components were conducted throughout the CEPP preliminary screening and alternative formulation effort (refer to Sections 3 and 4 of the CEPP PIR main report). For a more detailed assessment, the reader should refer to the complete suite of RSM-GL modeling results. A map of the RSM-GL gage locations is provided in **Figure C.2.1-49**.

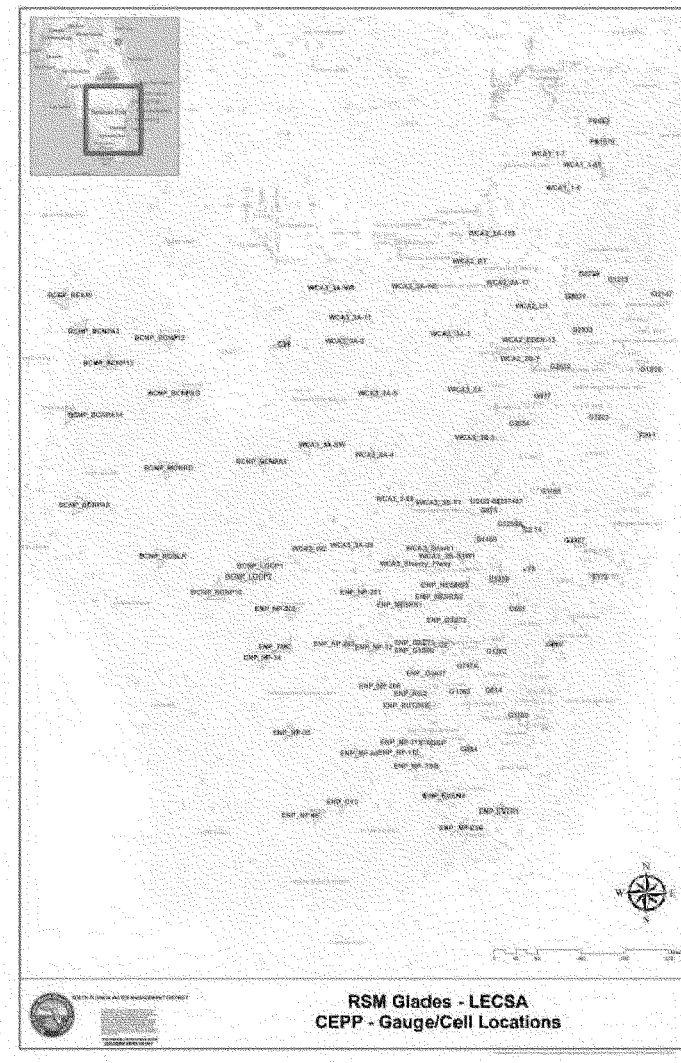


Figure C.2.1-49. Map of RSM-GL monitoring gage locations.

C.2.1.7.1 Lake Okeechobee and the Northern Estuaries

For the modeling of the final array of alternatives, operational changes to Lake Okeechobee were limited to changes within the flexibility of the Lake Okeechobee Regulation Schedule (LORS) 2008, with no adjustments to the defined LORS zones. Lake Okeechobee operational assumptions applied consistently for the final array modeling include changes to the decision tree outcome maximum allowable discharges dependant on Lake Okeechobee inflow forecasts, time of year (wet season or dry season), stage level (regulation zone), and/or stage trends (receding or ascending). The changes are all assumed to occur within the flexibility of LORS 2008 (Regulation Schedule zones unchanged), for the purpose of increasing CEPP potential benefits. Details pertaining to the proposed CEPP operations for Lake Okeechobee are separately addressed in the draft Preliminary Operations Manual (refer to **Annex C**).

Compared to the FWO, Lake Okeechobee stages are increased by 0.2-0.4 feet for the upper 60% of the stage duration curve, excluding extreme wet hydrologic conditions (**Figure C.2.1-50**). Peak lake stage increased from 17.50 feet NGVD in the FWO to 17.64 feet NGVD in the action alternatives. The number of days with stages above 16 feet NGVD is increased from 696 to 1096 during the 1965-2005 period of simulation.

For the Caloosahatchee Estuary, compared to the FWO, mean monthly flows above 2800 cfs and 4500 cfs are reduced by 13 and 2 months, respectively (16% and 6% reductions, respectively; **Figure C.2.1-51**). Mean monthly flows less than 450 cfs are reduced by 2 months (6%) (**Figure C.2.1-52**).

For the St. Lucie Estuary, compared to the FWO, mean monthly flows above 2000 cfs and 3000 cfs are reduced by 22 and 3 months, respectively (26% and 10% reductions, respectively; **Figure C.2.1-53**). Mean monthly flows less than 350 cfs are increased by 30 months (33%; **Figure C.2.1-54**). Note that the St. Lucie performance measures for the ECB and FWO base conditions were subsequently updated during development of the final array of alternatives, due to an identified error that the performance measure was not accounting for local groundwater flow contributions to the estuary. The correct St. Lucie estuary performance measure graphics are shown in **Figure C.2.1-53** and **Figure C.2.1-54**, although these graphics also include display of the subsequent CEPP action alternative 4R (discussed further in Appendix C.2.2).

Hydrologic effects to Lake Okeechobee and the Northern Estuaries would be the same for all action alternatives.

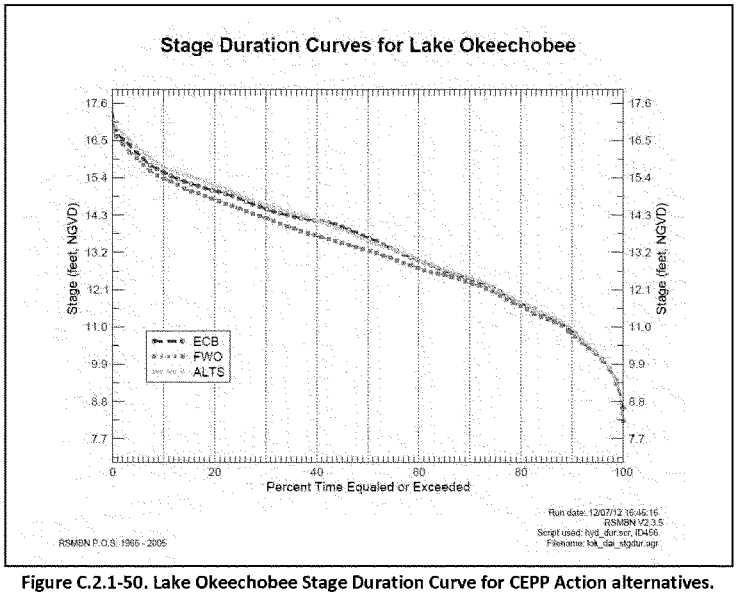


Figure C.2.1-50. Lake Okeechobee Stage Duration Curve for CEPP Action alternatives.

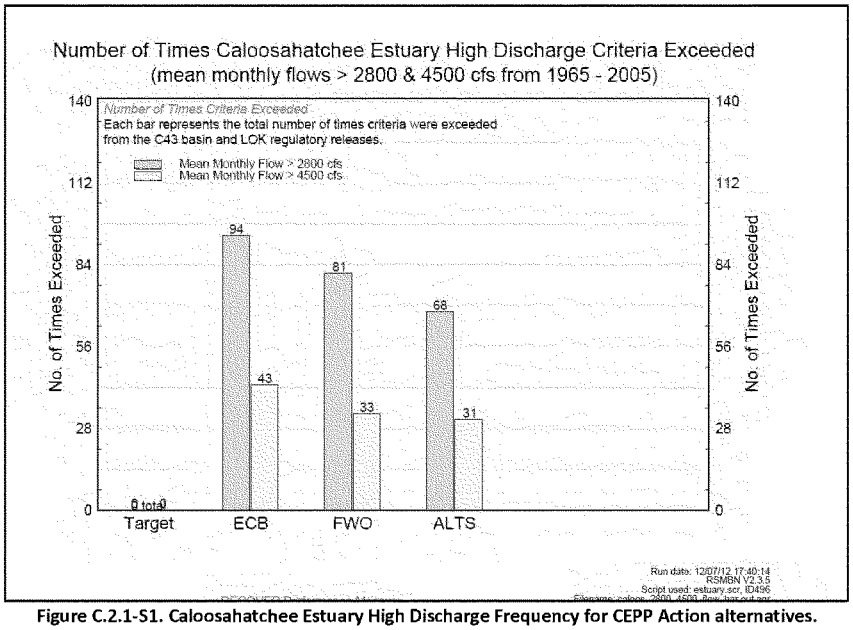


Figure C.2.1-S1. Caloosahatchee Estuary High Discharge Frequency for CEPP Action alternatives.

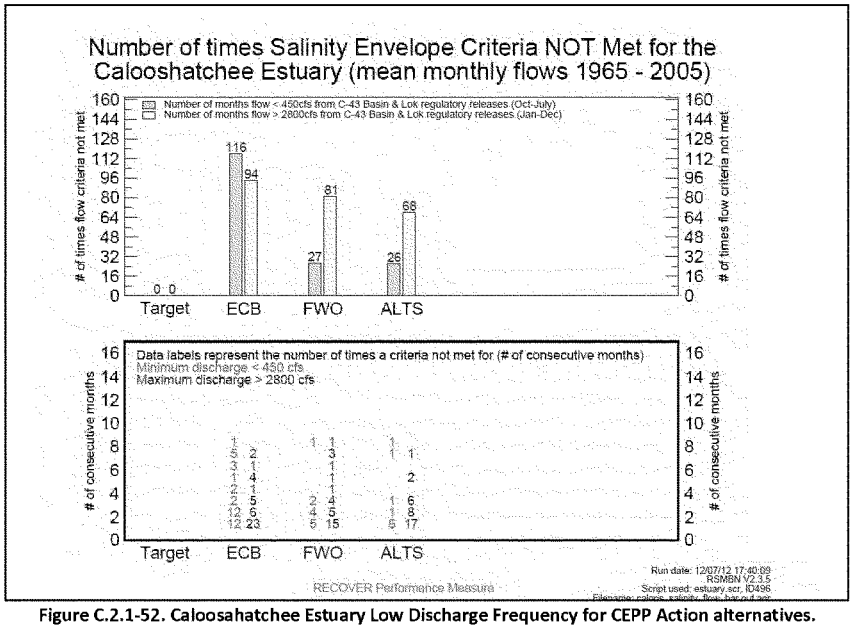


Figure C.2.1-52. Caloosahatchee Estuary Low Discharge Frequency for CEPP Action alternatives.

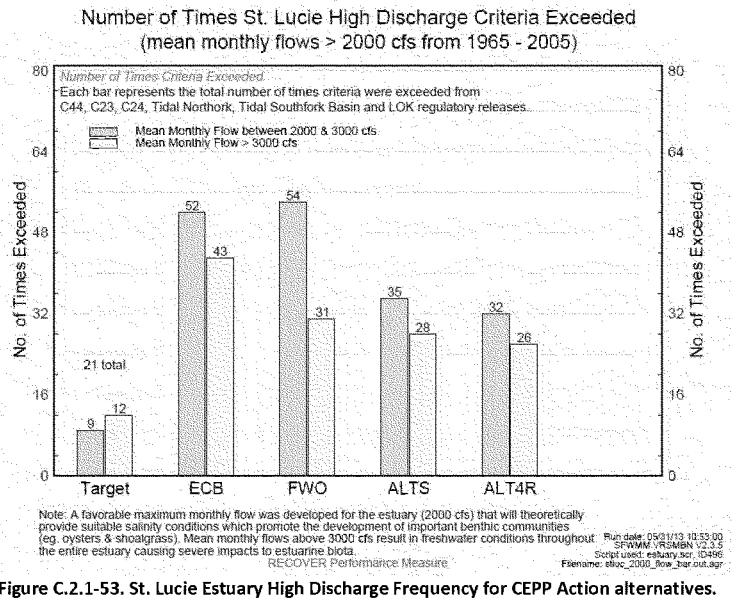


Figure C.2.1-53. St. Lucie Estuary High Discharge Frequency for CEPP Action alternatives.

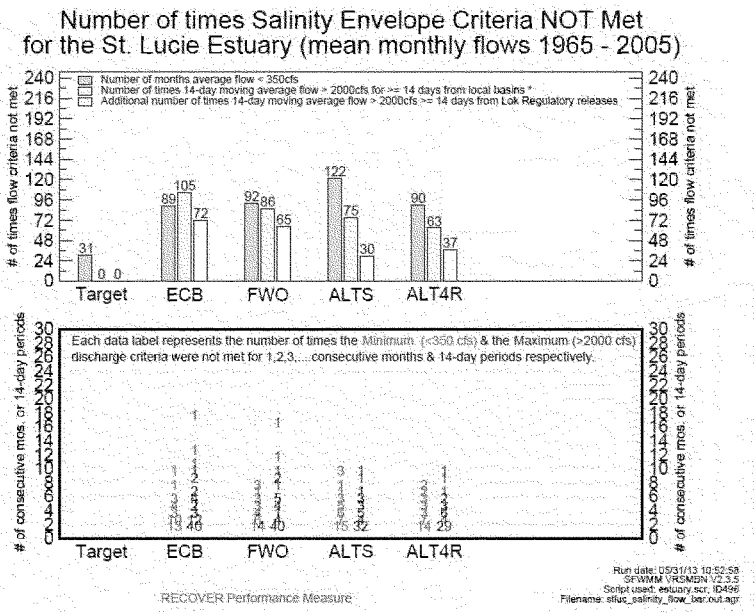


Figure C.2.1-54. St. Lucie Estuary Low Discharge Frequency for CEPP Baselines.

C.2.1.7.2 Everglades Agricultural Area

Minor changes to groundwater levels are expected adjacent to the proposed CEPP A-2 FEB (14,000 acres), compared to the FWO. The FWO condition and all action alternatives include the SFWMD Restoration Strategies A-1 FEB. The A-2 FEB design includes perimeter seepage collection canals and associated seepage pumps to limit potential impacts. Detailed CEPP assessments within the EAA are not available because the RSM-BN does not simulate groundwater within the EAA. Hydrologic effects to the Everglades Agricultural Area would be the same for all action alternatives.

C.2.1.7.3 Water Conservation Area 1

Compared to the FWO, no significant changes to WCA 1 stages are indicated with the action alternatives. Average annual regulatory releases from WCA 1 to WCA 2A via the S10 structures are slightly reduced from 268,000 acre-feet (268 kAF) to approximately 266 kAF with all action alternatives.

C.2.1.7.4 Water Conservation Area 2A and 2B

Compared to the FWO, WCA 2A stages are moderately decreased by 0.1-0.3 feet under all hydrologic conditions for Alts 1 through 4 (**Figure C.2.1-55**). Average annual inflows from STA 2 (including Compartment B) to WCA 2A are significantly decreased from 381 kAF to 218 kAF (a 43% decrease) with the assumed implementation of the L-6 diversion from WCA 2A to WCA 3A. The S-7 pump station also contributes inflows to WCA 2A; S-7 inflows are reduced from 77 kAF in the FWO to 16 kAF in Alts 1 through 4, due to operations to redirect a portion of STA-3/4 discharges away from WCA 2A to WCA 3A via the S-8 pump station. Average annual regulatory releases from WCA 2A to WCA 3A via the S11s are significantly decreased from 460 kAF to 287-288 kAF for Alts 1 through 4.

Compared to the FWO, stages within WCA 2B are significantly decreased by 0.50-0.75 feet under nearly all hydrologic conditions, excluding extreme wet conditions, for Alts 1 through 4 (**Figure C.2.1-56**). Changes within WCA 2B are directly related to the decreased stages within WCA 2A and decreased inflows from S-144, S-145, S-146, and seepage.

C.2.1.7.5 L-28 Triangle

The L-28 Triangle area is located entirely within the boundaries of the Miccosukee Tribe of Indians of Florida's Reservation and encompasses 7830 acres of Tribal lands and approximately 230 acres of BCNP. The L-28 Triangle area is confined on north by Interstate 75, the west by L-28 Interceptor Canal (L-28I) and the BCNP, and the east by the L-28 Canal.

The L-28 Interceptor Canal is bound by levees on both sides and maintains no direct connection to wetlands in the Triangle. Within the L-28 Triangle Area, the L-28 Canal is bound on the east side by a confining levee separating the wetlands of the L-28 Triangle from WCA 3A.Wetlands interior to the L-28 Triangle do maintain a connection to the L-28 canal along the west side of the L-28 canal. The L-28 canal terminates at the southern tip and is not connected to the L-28I canal. Historically the S-140 pump station maintained flood protection within the Triangle. A weir was installed in 2009, within the L-28 Canal and immediately south of Interstate 75, to restrict regional pumping and maintain water within the Triangle.

Alternative 1 includes removal of two segments of the L-28 Levee along the eastern boundary of the L-28 Triangle (9000 feet total) and complete backfill of the L-28 Canal segment located between the levee gaps, as shown in **Figure C.2.1-57**. By re-establishing a surface water hydrologic connection between WCA 3A and the L-28 Triangle, stages within the Triangle are generally increased by 0.2-0.5 feet during nearly all hydrologic conditions, excluding the driest 25% of hydrologic conditions, with no significant change to stages within the adjacent WCA 3A (**Figure C.2.1-58**). Although Alts 2 through 4 do not include modifications to the L-28 Levee or the adjacent canal, stages within the L-28 Triangle are slightly increased by 0.1-0.2 feet during normal to dry conditions, due to groundwater interactions with the down-gradient western WCA 3A marsh.

C.2.1.7.6 Big Cypress National Preserve

Stages within the BCNP, west of WCA 3A and Western Shark River Slough (ENP), do not change significantly between the CEPP FWO and the CEPP action alternatives.

C.2.1.7.7 Water Conservation Area 3A and 3B

The hydrologic effects of the CEPP action alternatives include the combined effects from implementation of the A-2 FEB, the L-6 Diversion, the northern WCA 3A hydropattern restoration components along L-4 (all action alternatives) and L-5 (Alts 2 through 4), the Miami Canal backfill (north of Interstate 75), and the proposed new or expanded WCA 3A outlet structures along L-67A, along with the associated operations. Compared to the FWO, average annual combined structural inflows to WCA 3A from STA 3/4, STA 5/ STA 6 (including Compartment C), and WCA 2A are significantly increased from 1,028 kAF to 1,274-1,275 kAF (a 24% increase) following implementation of the CEPP components. In order to avoid adverse increases to the frequency, duration, and peak stages of WCA 3A high water conditions with this net increase in WCA 3A inflows, average annual combined structural outflows from WCA 3A through S-151 (to WCA 3B), S-333 (to ENP NESRS), the S-12 structures (to ENP WSRS), and the S343/S344 culverts are also significantly increased from 1,190 kAF in the FWO to 1,303-1,482 kAF for Alts 1 through 4 (1,425 kAF for Alt 1; 1,482 kAF for Alt 2; 1,303 kAF for Alt 3; and 1,436 kAF for Alt 4).

Since WCA 3A covers approximately 752 square miles, hydrologic differences between the CEPP FWO and Alts 1 through 4 are characterized at representative gages throughout WCA 3A.

Within northwest WCA 3A, compared to the FWO, stages are generally significantly increased by 0.6-0.8 feet for Alt 1 and significantly increased by 0.5-0.7 feet for Alts 2 through 4 **(Figure C.2.1-59)**. Stages within northeast WCA 3A are generally significantly increased by 0.4-0.7 feet for Alt 1 and significantly increased by 0.5-0.8 feet for Alts 2 through 4, with no significant change during extreme wet conditions and a slight increase in stage for extreme dry conditions (**Figure C.2.1-60**). Within east-central WCA 3A (3A-3), stages are generally significantly increased by 0.2-0.6 feet, with no significant change during the wettest 20% of conditions for Alts 1 through 4 (**Figure C.2.1-61**). Proceeding south within central WCA 3A (3A-4), stages are generally increased by 0.1-0.2 feet during average to dry conditions, with a slight depth reduction during the wettest 10% of conditions and no significant change during extreme dry conditions for Alts 1 through 4 (**Figure C.2.1-62**). Southern WCA 3A (3A-28) stages are decreased by 0.1-0.2 feet during the wettest 5% of conditions and slightly decreased during normal to dry conditions for Alts 1 and 4 (**Figure C.2.1-63**); for Alts 2 and 3, southern WCA 3A stages are decreased by 0.1-0.2 feet during the wettest 5% of conditions and decreased by 0.1-0.2 feet during wet, normal, and dry conditions.

The CEPP FWO includes the existing S-151 gated culvert as the sole structural inflow to WCA 3B (327 kAF average annual) and the existing S-355 A and B spillways as the only structural outflows from WCA 3B (<2 kAF average annual). By contrast, the CEPP action alternatives have between 1 and 4 new inflow structures to WCA 3B along L-67A (in addition to increased capacity at S-333), resulting in an additional WCA 3B inflow design capacity of between 750-2,000 cfs. The WCA 3B outflow configurations also incorporate a similar wide range of variability: the existing S-355s only (FWO, Alt 1); one additional 500 cfs western gravity structure (Alt 2); two additional 500 cfs pump stations (Alt 3); and additional removal of the L-29 Levee within the Blue Shanty flowway (Alt 4). Water budget maps with surface water flow vectors for Alts 1 through 4, focusing primarily on the structure flows (kAF average annual) and locations (levee seepage flux along L-30 and L-29 is also indicated), are provided in **Figure C.2.1-64** through **Figure C.2.1-67**. Only Alt 3 (with L-29 pumps) and Alt 4 (with the Blue Shanty flowway and L-29 Levee Gap) achieve any significant degree of north-to-south surface water flow directionality within WCA 3B, due to the CEPP prescribed limitations on WCA 3B high water stages (east of the Blue Shanty flowway only in Alt 4) and the increased down-gradient water stages in the L-29 Canal. Peak stages within central WCA 3B (Site 71) exceed 9.0 feet NGVD between 0-2% of the RSM-GL 1965-2005 period of simulation, and only Alt 2 results in WCA 3B stages above 8.0 feet NGVD for more than 20% or the period of simulation.

The WCA 3B hydrologic effects, resultant from the water budget differences, also vary significantly between the action alternatives. At Site 71 for Alt 1, WCA 3B stages are increased by 0.1-0.2 feet during the wettest 10% of conditions and during normal to dry conditions, compared to the FWO; for Alt 2, stages are significantly increased by 0.3-0.5 feet under all hydrologic conditions; for Alt 3, stages are significantly increased by 0.2-0.3 feet during the wettest 10% of conditions and during normal to dry conditions; for Alt 4, stages are slightly increased during the wettest 10% of conditions and increased by 0.1-0.2 feet during normal to dry conditions (**Figure C.2.1-68**). For Alt 4, the stage duration curves for stages within the interior of the Blue Shanty flowway and the down-gradient L-29 Canal stages are shown in **Figure C.2.1-69**; for Alt 4, the peak stage within the Blue Shanty flow-way is 9.73 feet NGVD and stages exceed 8.0 feet NGVD for approximately 45% of the period of simulation.

C.2.1.7.8 Northeast Shark River Slough

The CEPP action alternatives assume the L-29 Canal maximum operational limit at 9.7 feet NGVD (7.5 feet NGVD is used for the ECB and FWO) and removal of the G-3273 stage constraint (6.8 feet NGVD is used for the ECB and FWO). Total net structural inflows to NESRS (via the L-29 Canal; computed as the sum of S-333, S355A, S-355B, L-29SA, L-29PA, L-29PB, L29 Levee Gap, and S-356 minus S-334) are significantly increased compared to the CEPP FWO (94 kAF average annual): 736 kAF for Alt 1; 740 kAF for Alt 2; 797 kAF for Alt 3; and 717 kAF for Alt 4. Only Alt 3 (with L-29 pumps) and Alt 4 (Blue Shanty flowway and L-29 Levee Gap) deliver a significant portion of these NESRS deliveries through WCA 3B, with 52% and 23% respectively (Alt 1 – 1%; Alt 2 – 4%), due to the CEPP prescribed limitations on WCA 3B high water stages (east of the Blue Shanty flowway only in Alt 4) and the increased down-gradient water stages in the L-29 Canal.

Stage duration curves for the L-29 Canal are provided in **Figure C.2.1-70** and **Figure C.2.1-71** (upper 25% only) (note: for Alt 4, L-29 Canal stages are indicated west of the proposed L-29 divide structure). For the CEPP action alternatives, peak stages in the L-29 Canal range between 9.57-9.63 feet NGVD (the FWO peak stage is 8.43 feet NGVD). Based on the assumed operational constraints, the CEPP FWO L-29 Canal stage exceeds the maximum operational limit of 7.5 feet NGVD approximately 6% of the 1965-2005 RSM-GL period of simulation (due to direct rainfall); by contrast, the maximum operational limit prescribed for the CEPP action alternatives is not constraining during any period within the period of simulation, and L-29 Canal stages exceed 8.5 feet NGVD during only approximately 10-13% of the period of simulation.

Compared to the FWO, stages are significantly increased by 0.7-1.0 feet under all hydrologic conditions at NESRS-2 for Alts 1 through 4 (**Figure C.2.1-72**). Similar trends are also observed further south at the NESRS-1 monitoring gage. Changes to the average annual overland flow to NESRS across RSM-GL transect 18 are shown in **Figure C.2.1-74**; a reference map for the RSM-GL transects (which are consistent with the SFWMM model transects, adjusted for the RSM grid resolution) is provided as **Figure C.2.1-73**.

C.2.1.7.9 Western Shark River Slough

Western SRS (WSRS), located to the west of L-67 Extension Levee and bounded on the north by Tamiami Trail, is primarily influenced by rainfall and water management operations at the S-12 structures (A, B, C and D). Under ERTP, the utilization of the S-12 structures and the seasonal sequential closure periods beginning from the west at S-12A (November 1 – July 14) and S-12B (January 1 – July 14), respectively, is meant to move water from WCA 3A into SRS while providing conditions for Cape Sable seaside sparrow Subpopulation-A (CSSS-A) nesting and breeding. Modification to the ERTP seasonal closure periods for the S-12A and S-12B was not considered during CEPP preliminary screening and alternative formulation, based on USACE consideration of the USFWS Biological Opinion for ERTP.

Changes to the average annual overland flows to WSRS across RSM-GL transect 17 are shown in **Figure C.2.1-75**. Compared to the FWO, stages within northwest ENP (NP-201) are generally significantly decreased by 0.1-0.4 feet under all hydrologic conditions for Alt 1 (**Figure C.2.1-76**). For Alt 2 and Alt 3, NP-201 stages are slightly decreased during wet conditions, slightly increased during normal conditions, and decreased by 0.1-0.3 feet under normal to dry conditions; similarly, for Alt 4, NP-201 stages are slightly decreased during extreme wet conditions, increased by 0.1-0.2 feet during normal conditions, and decreased by 0.1-0.2 feet under normal to dry conditions. To the south and west, the NP-205 monitoring gage (used as an indicator for CSSS -A hydrology) indicates a potentially significant stage decrease of 0.1-0.2 feet under all hydrologic conditions for all action alternatives, compared to the FWO

(**Figure C.2.1-77**). Stages further south within Central Shark River Slough (P-33) are generally significantly increases by 0.2-0.6 feet under all hydrologic conditions for all action alternatives (**Figure C.2.1-78**). Stages within Central Shark River Slough demonstrate a combined hydrologic response to the hydrologic changes previously indicated for both NESRS and WSRS; the resultant combined average annual transect flows within Central Shark River Slough (Transect 27) are significantly increased compared to the FWO (average annual 594 kAF): 812 kAF for Alt 1 (37% increase); 786 kAF for Alt 2 (32%); 842 kAF for Alt 3 (42%); and 856 kAF for Alt 4 (44%) (**Figure C.2.1-79**).

C.2.1.7.10 Taylor Slough

Compared to the FWO, ENP stages along Taylor Slough (NP-TSB) are slightly increased by approximately 0.1 feet during the wettest 20% of hydrologic conditions for Alt 1 through 3 (**Figure C.2.1-80**). By comparison, for Alt 4, which includes the Blue Shanty flowway and the L-29 divide structure to direct surface water flows further west within NESRS, ENP stages along Taylor Slough are slightly decreased by approximately 0.1 feet during the wettest 30% of hydrologic conditions.

C.2.1.7.11 Lower East Coast Area

The LEC area is located to the east of the L-31N, L-31W, and C-111 canals. Under the FWO (ERTP), specified canal water levels/ranges are meant to provide flood protection, water supply, and prevention of saltwater intrusion for the LEC. For the CEPP final array of alternatives, the operations for the SDCS are changed from the FWO operations for G-211 and the coastal canals are utilized to convey seepage water to Biscayne Bay to offset for reduced flows caused by implementation of CEPP.

Observed stage changes within the LEC are separately discussed with the summary of flood control and water supply performance for the CEPP action alternatives, included in **Section C.2.1.8**.

C.2.1.7.12 8.5 Square Mile Area

The CEPP action alternatives modify the FWO operations of the S-357 pump station, in an effort to increase discharges from the 8.5 SMA detention cell to the C-111 South Dade North Detention Area and reduce the reliance on the S-331 pump station in L-31N to provide flood mitigation for the 8.5 SMA protected area. Details of the S-357 operations are provided with the documentation of the modeling assumptions for the CEPP action alternatives, located in Annex A-2 of the Engineering Appendix (Appendix A). The protected portion of the 8.5 SMA is represented by three model grid cells in the RSM-GL (**Figure C.2.1-81**), and the resolution of the RSM-GL is extremely limiting for adequate representation of the 8.5 SMA project features. Prior to implementation of CEPP, further technical investigations will likely be needed for the 8.5 SMA operations, and additional hydrologic/hydraulic modeling with a higher resolution model may be required.

Stages within the 8.5 SMA, located along the eastern boundary of ENP, are lowered by approximately 0.25 feet during wet conditions for RSM-GL grid cells 2965 and 2962, compared to the FWO (**Figure C.2.1-81**); within the resolution of the RSM-GL model, these grid cells represent northern and eastern 8.5 SMA respectively. However, stages within the southwest portion of the 8.5 SMA protected area, represented by RSM-GL grid cell 2749, are increased by approximately 0.3-0.6 feet under all hydrologic conditions.

C.2.1.7.13 Biscayne Bay

Combined total average annual surface water canal discharges to central and southern Biscayne Bay (S-336, S-338, S-194, S-196, S-197) are reduced by between 23-24 kAF for Alts 1 and 2, reduced by 44 kAF

for Alt 3, and reduced by 37 kAF for Alt 4. Average annual surface water canal discharges to northern Biscayne Bay (S-29, S-28, S-27), which are affected by the assumed operations of the CERP BCWPA project, are unchanged for Alt 1, increased by 14 kAF for Alt 2, slightly reduced by 3 kAF for Alt 3, and reduced by 7 kAF for Alt 4R2.

C.2.1.7.14 Florida Bay

For the CEPP action alternatives, average annual surface water transect flows from southeastern ENP towards Florida Bay are increased by 2-3 kAF (7-11%) for Craighead Basin (RSM-GL Transect 23-A), increased by 5 kAF (7%) from Taylor Slough (Transect 23-B), and increased by 0-2 kAF (<1%) for the Eastern Panhandle of ENP (Transect 23-C), resulting in a net increase of approximately 7-10 kAF for the action alternatives, compared to the FWO. The salinity effects within Florida Bay from this overall increase and changed spatial distribution of flows were also evaluated by the CEPP ecological sub-team (with additional RECOVER support), and additional information for the changes observed between the CEPP action alternatives and the FWO is discussed in **Appendix G, Environmental Benefits Model**.

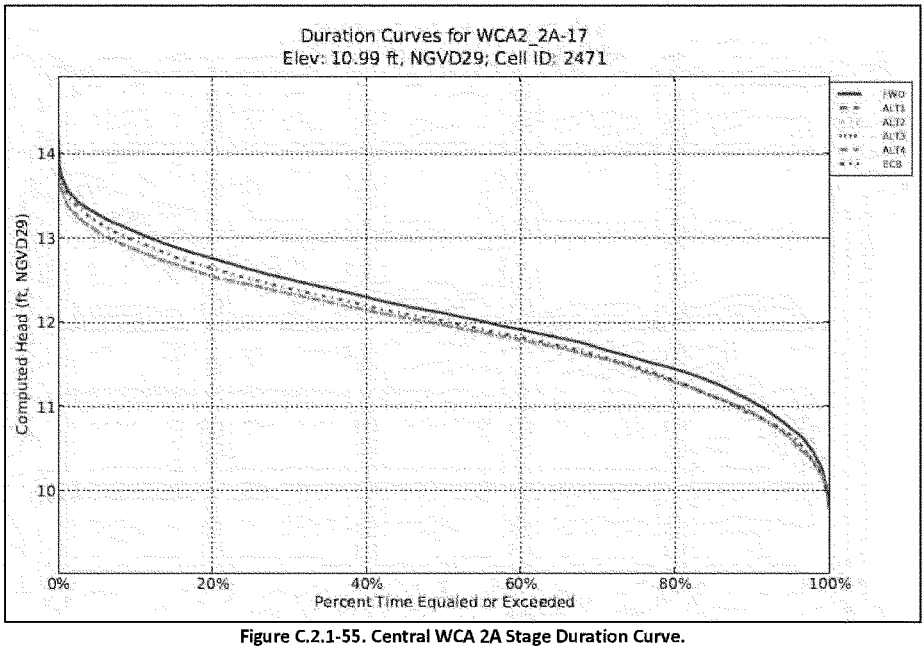


Figure C.2.1-55. Central WCA 2A Stage Duration Curve.

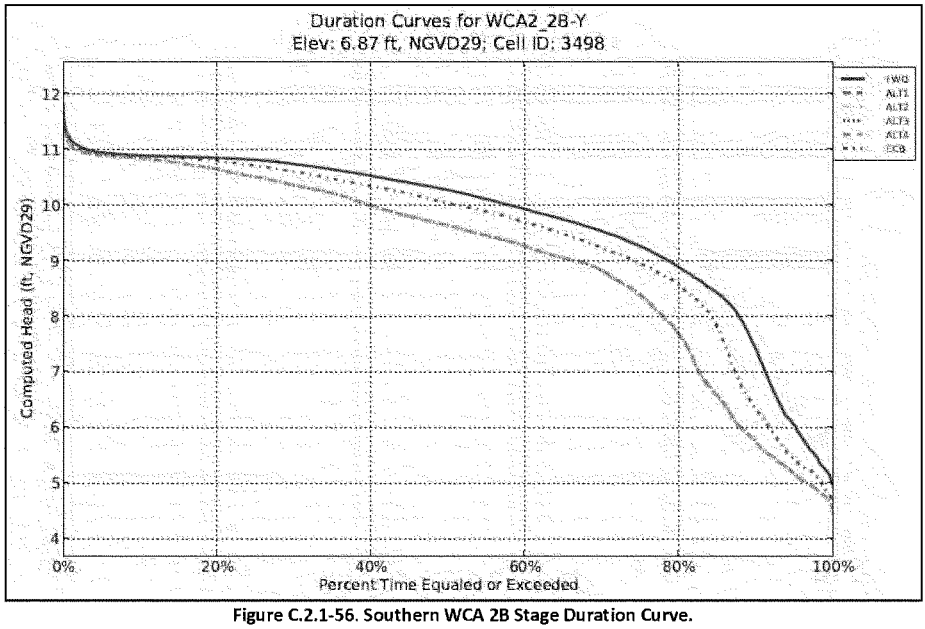


Figure C.2.1-56. Southern WCA 2B Stage Duration Curve.

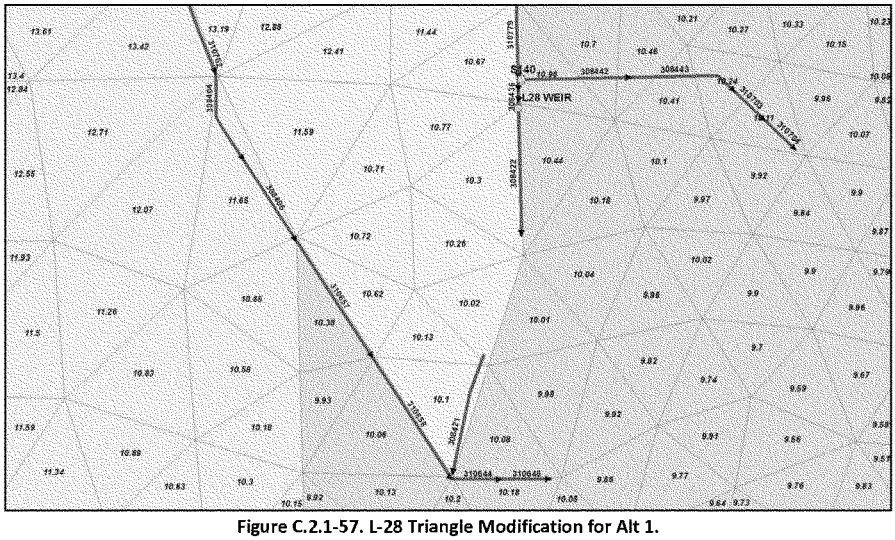


Figure C.2.1-57. L-28 Triangle Modification for Alt 1.

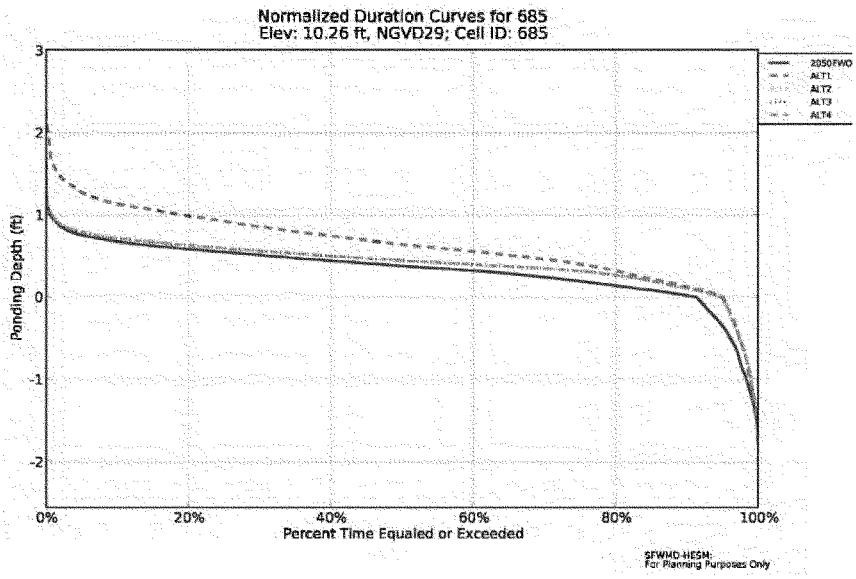


Figure C.2.1-58. L-28 Triangle Stage Duration Curve.

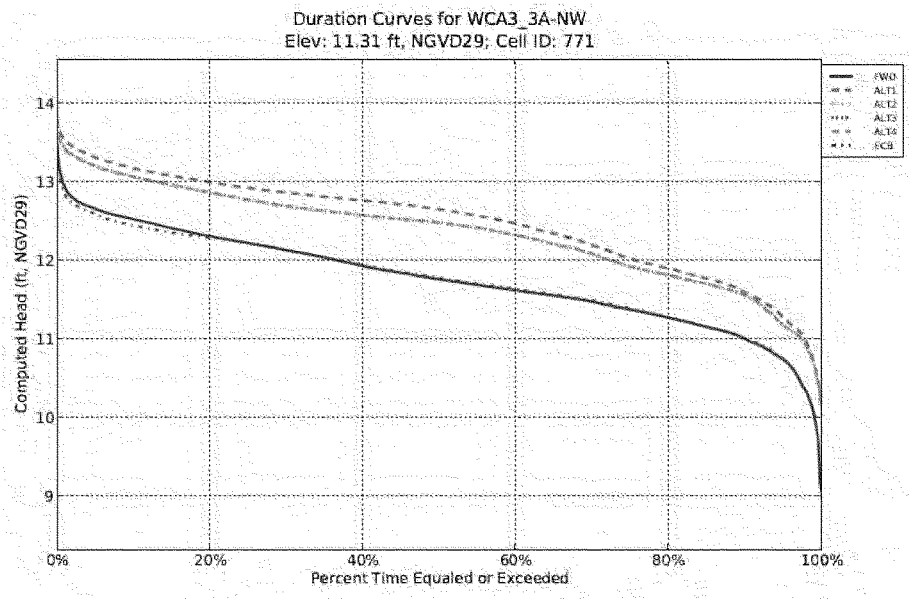


Figure C.2.1-59. Northwest WCA 3A Stage Duration Curve.

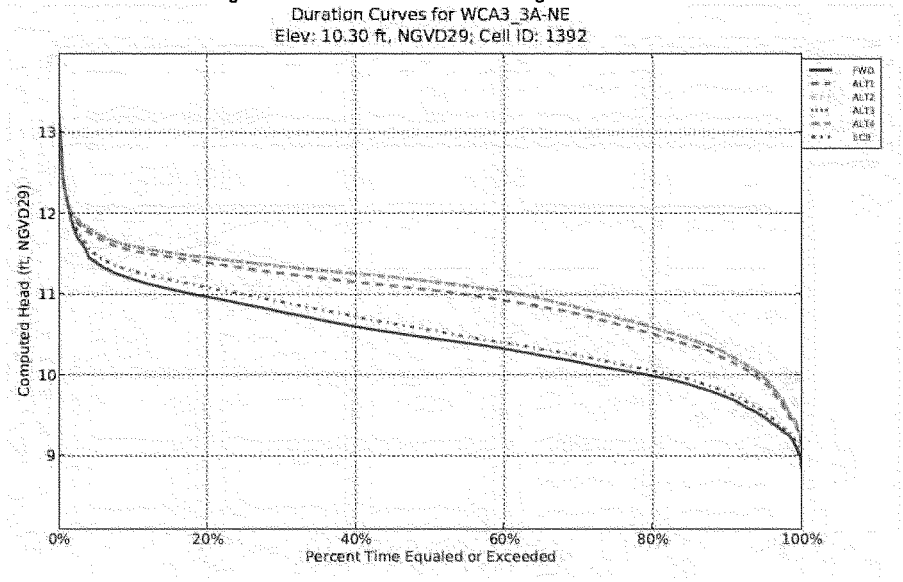


Figure C.2.1-60. Northeast WCA 3A Stage Duration Curve.

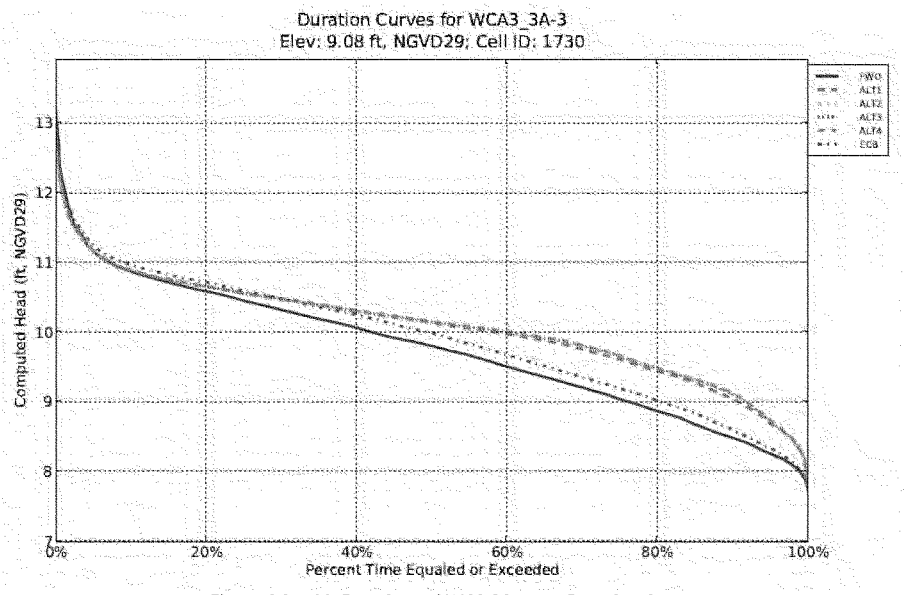


Figure C.2.1-61. East-Central WCA 3A Stage Duration Curve.

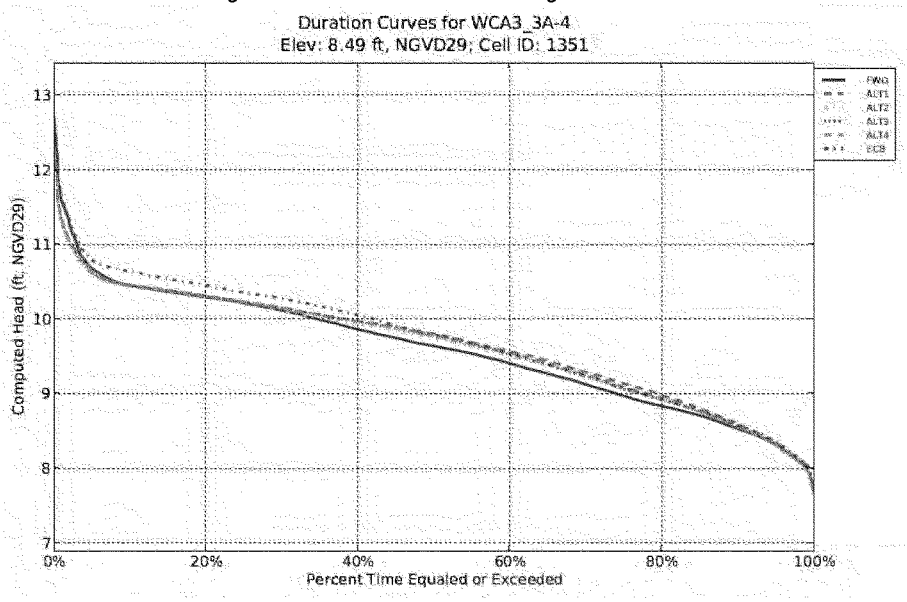


Figure C.2.1-62. Central WCA 3A Stage Duration Curve.

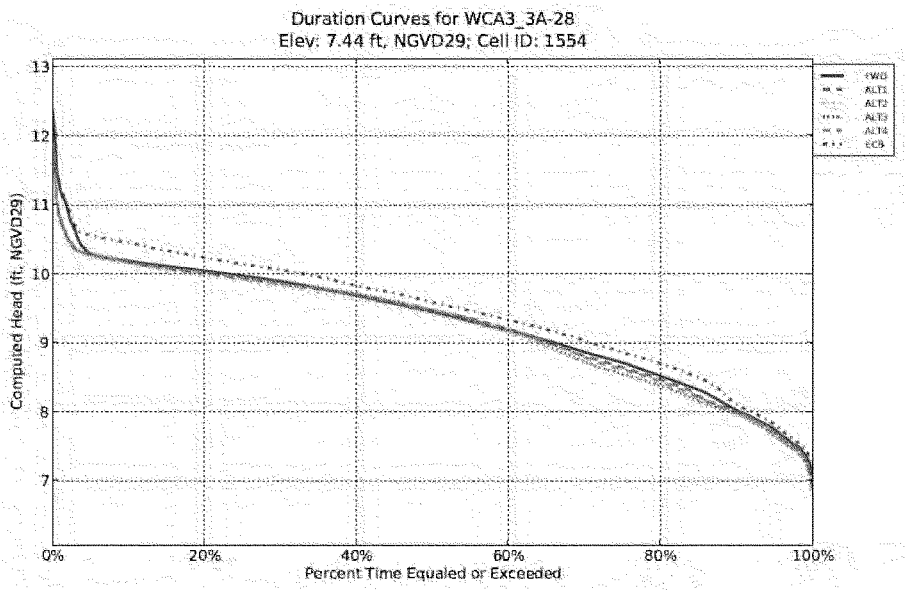


Figure C.2.1-63. South WCA 3A Stage Duration Curve.

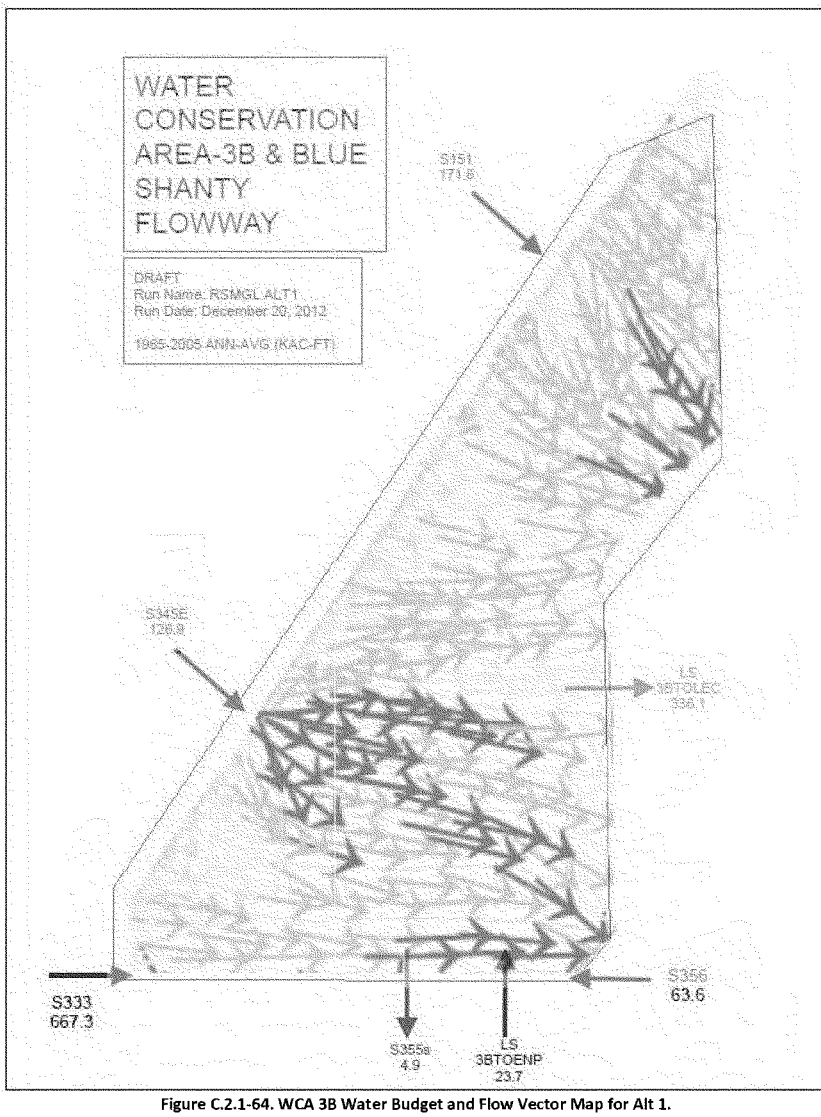


Figure C.2.1-64. WCA 3B Water Budget and Flow Vector Map for Alt 1.

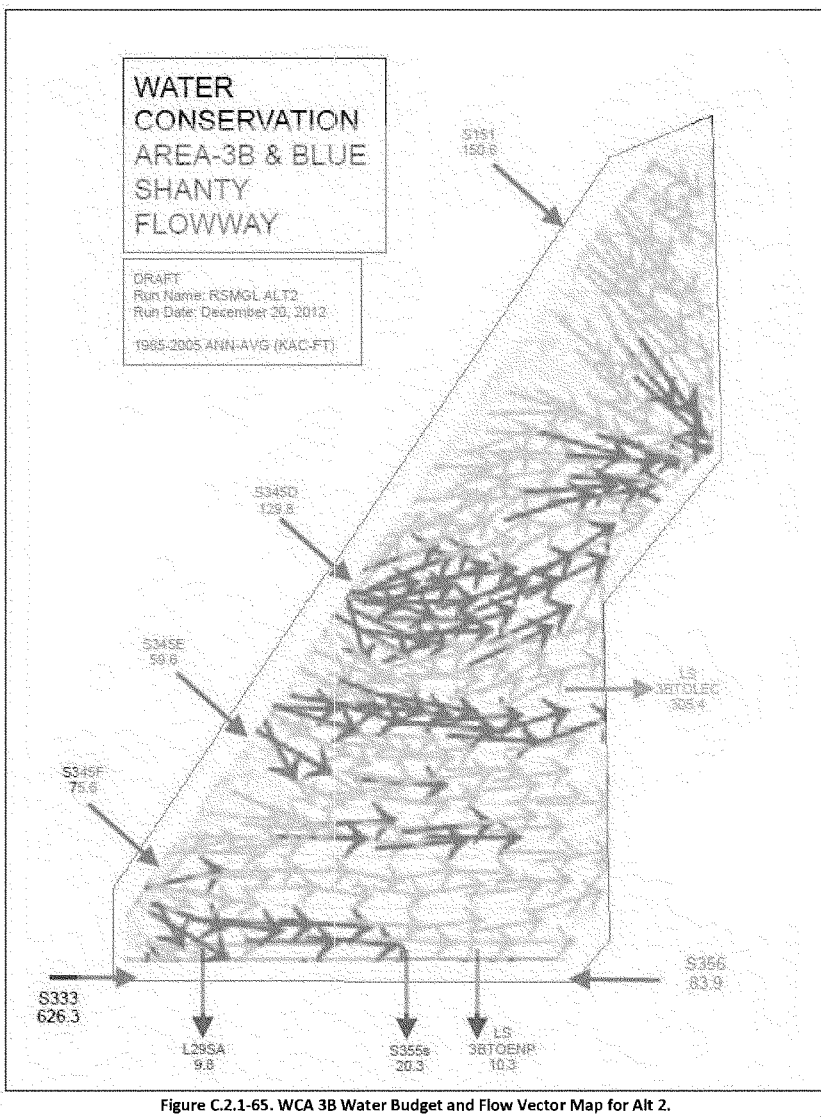


Figure C.2.1-65. WCA 3B Water Budget and Flow Vector Map for Alt 2.

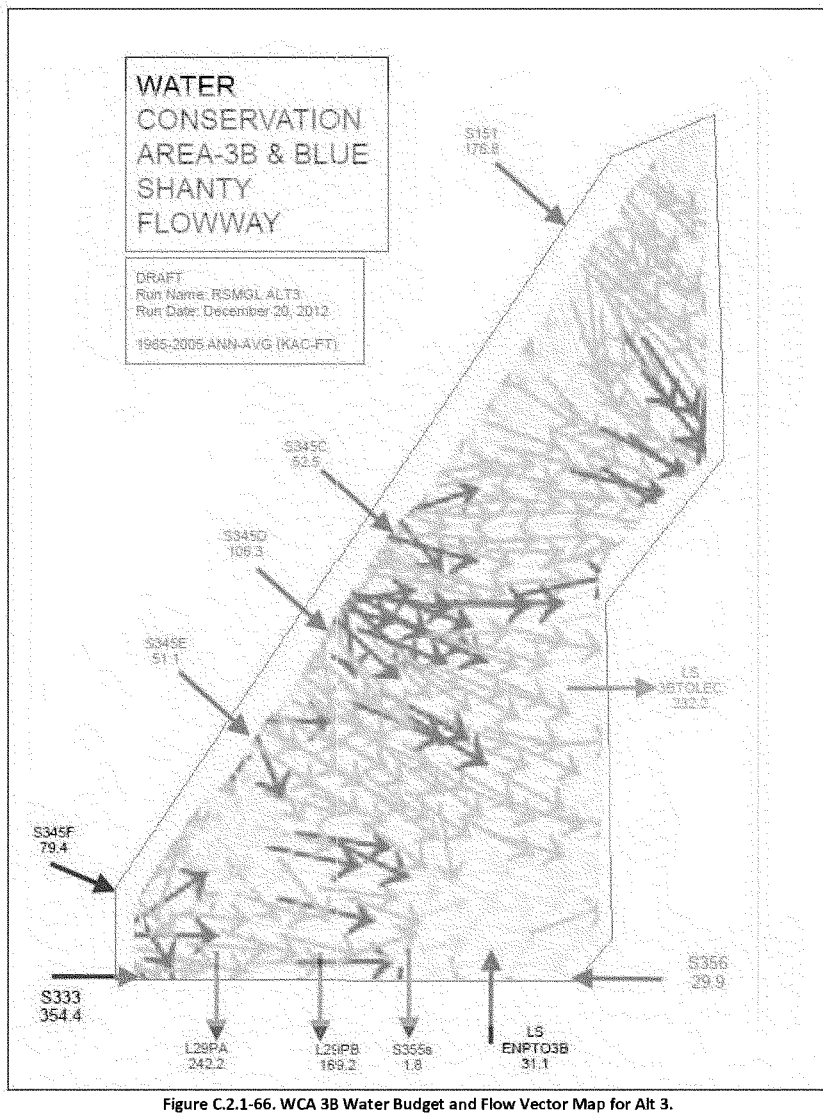


Figure C.2.1-66. WCA 3B Water Budget and Flow Vector Map for Alt 3.

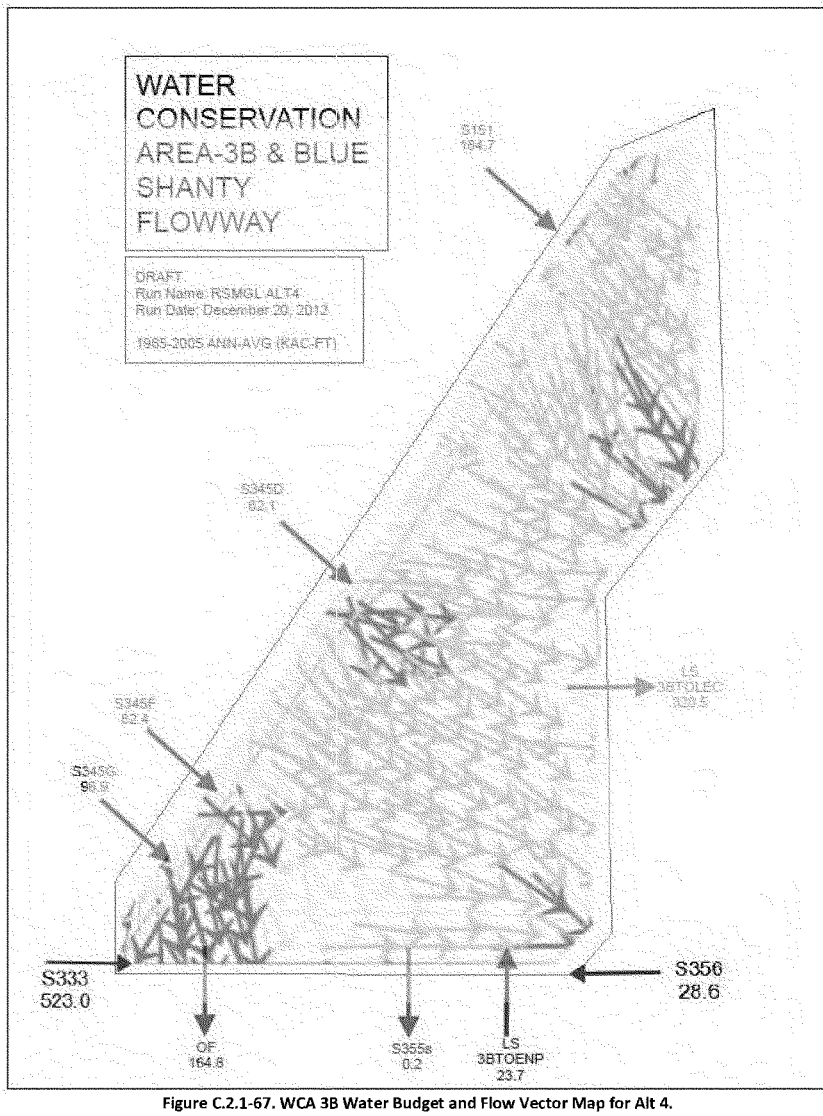


Figure C.2.1-67. WCA 3B Water Budget and Flow Vector Map for Alt 4.

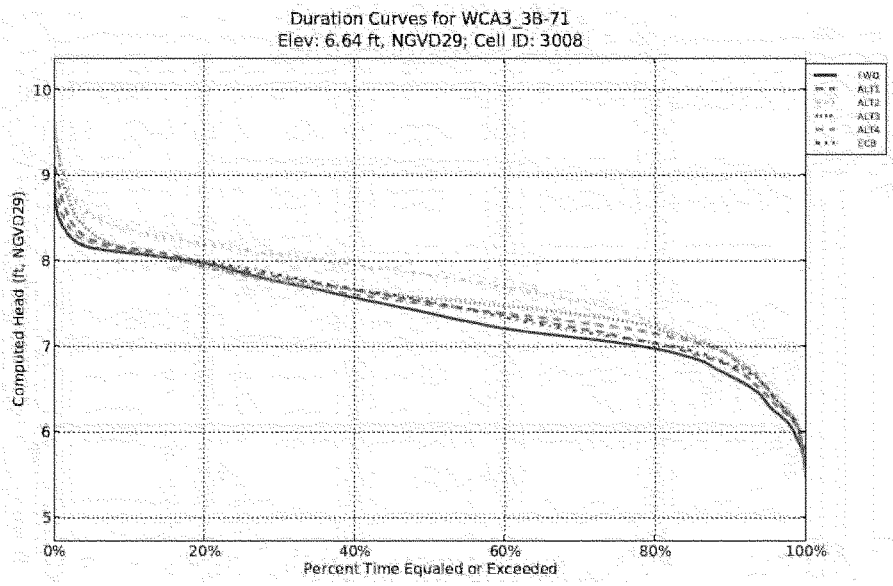


Figure C.2.1-68. Central WCA 3B Stage Duration Curve.

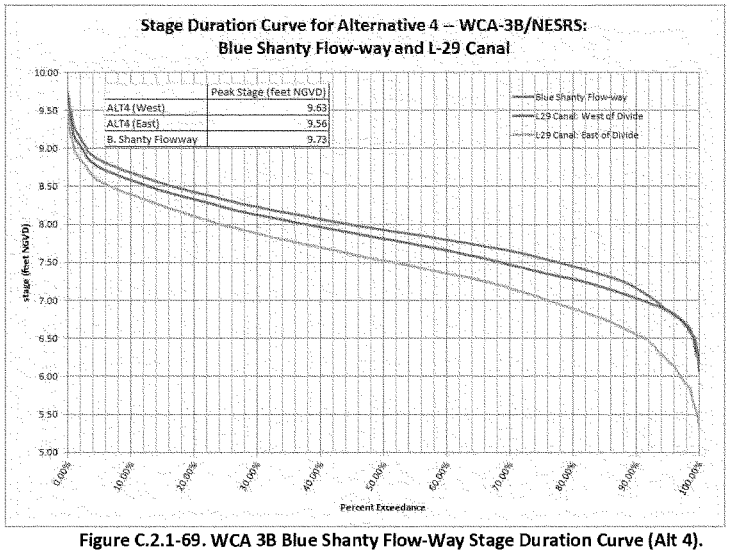


Figure C.2.1-69. WCA 3B Blue Shanty Flow-Way Stage Duration Curve (Alt 4).

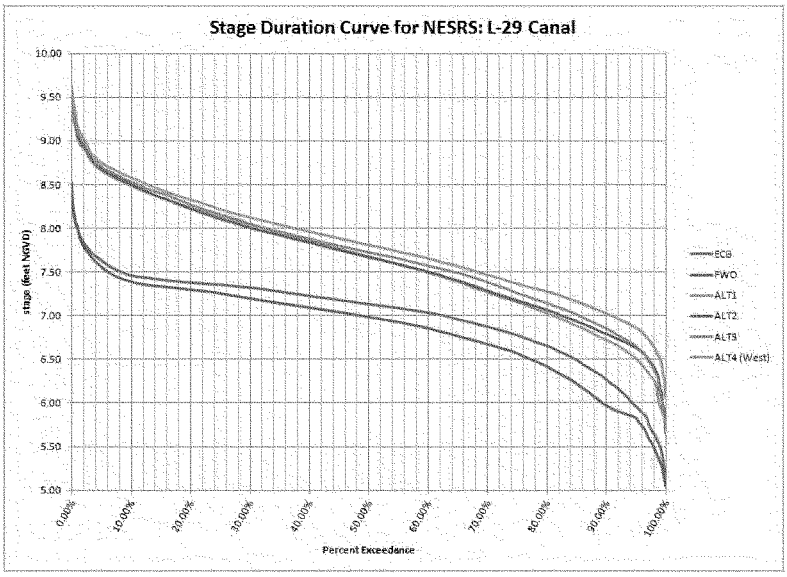


Figure C.2.1-70. L-29 Canal Stage Duration Curve.

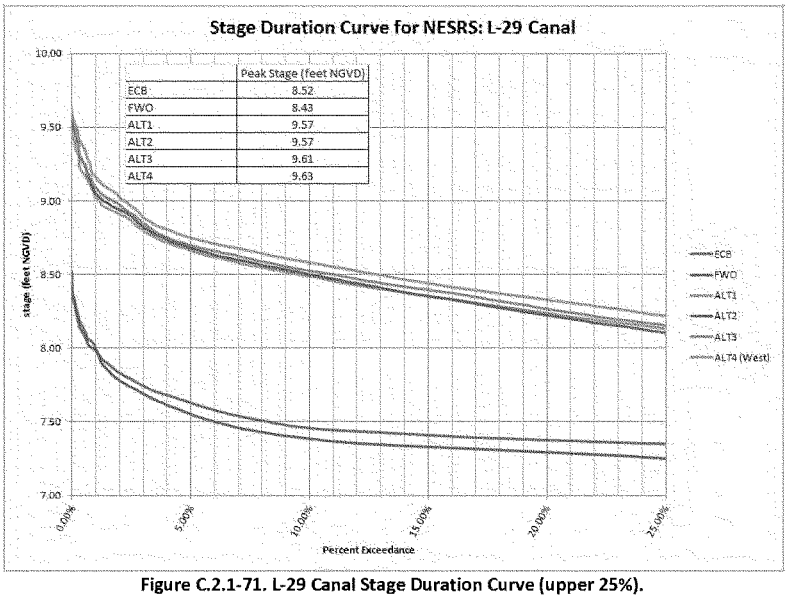


Figure C.2.1-71. L-29 Canal Stage Duration Curve (upper 25%).

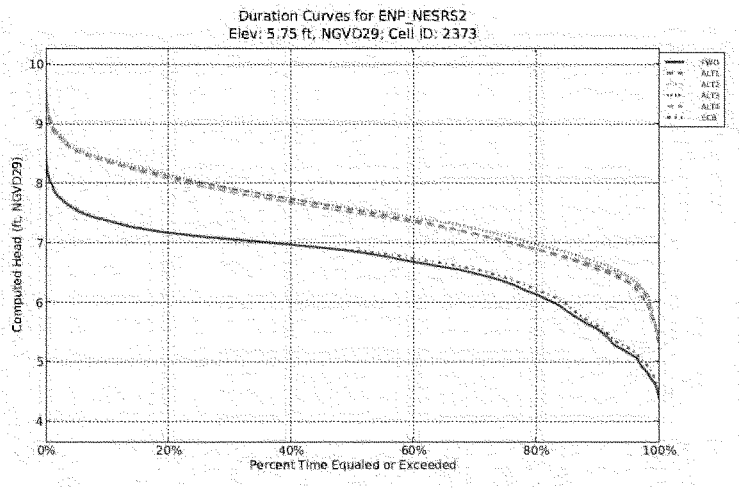


Figure C.2.1-72. Northeast ENP Stage Duration Curve.

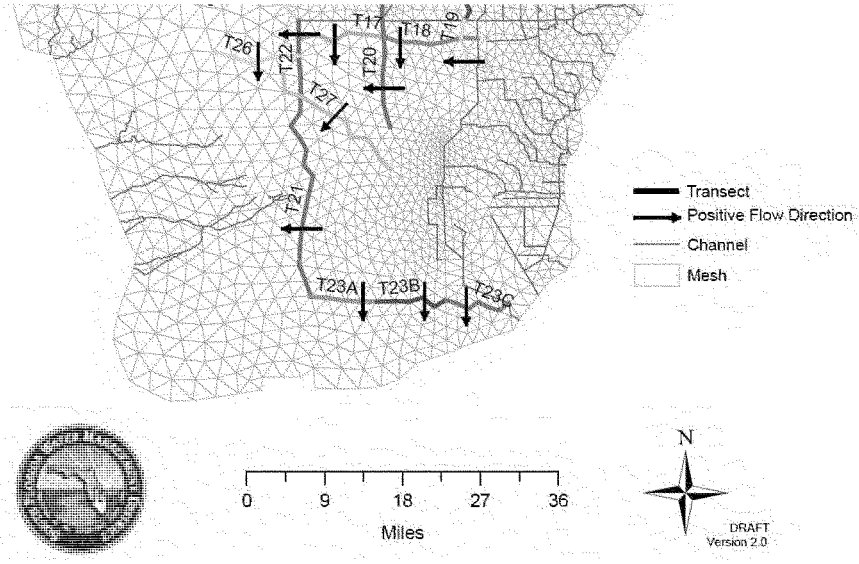


Figure C.2.1-73. RSM-GL Overland Flow Transects for ENP.

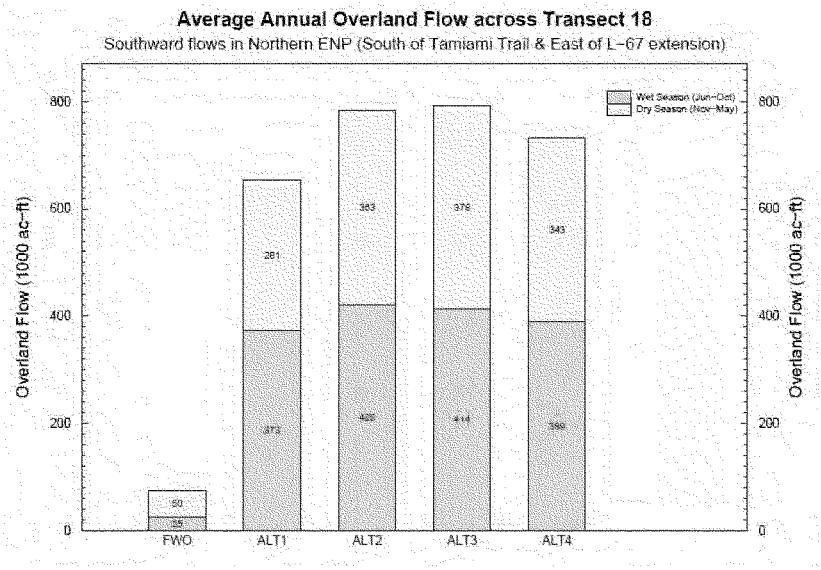


Figure C.2.1-74. Average Annual Overland Flow to NESRS.

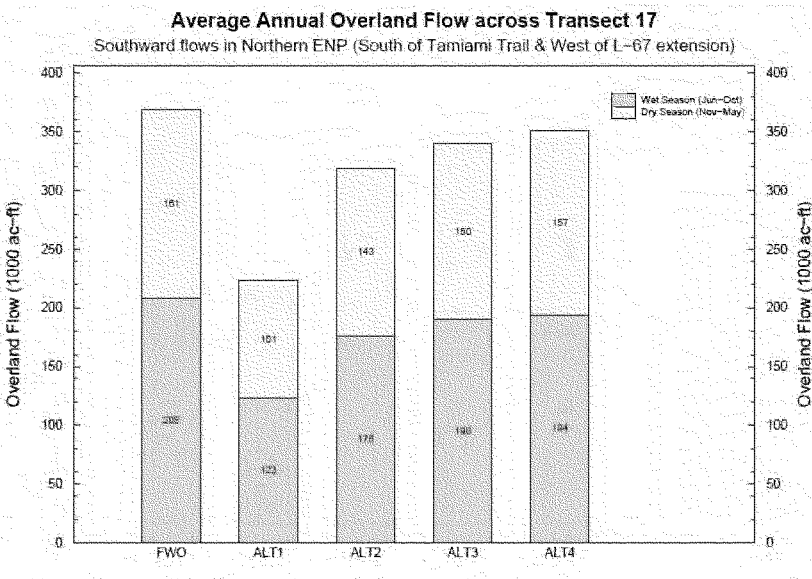


Figure C.2.1-75. Average Annual Overland Flow to WSRS.

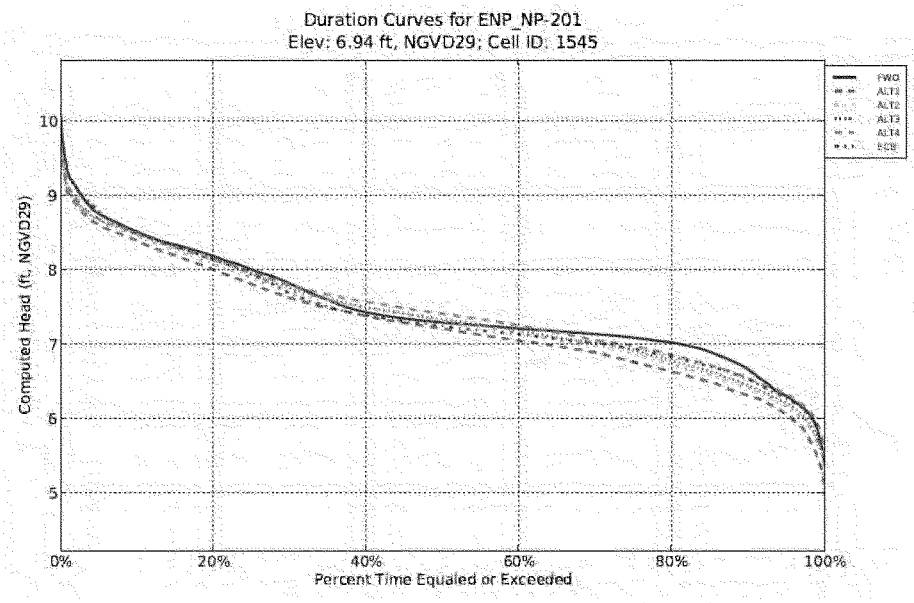


Figure C.2.1-76. Northwest ENP Stage Duration Curve (NP-201).

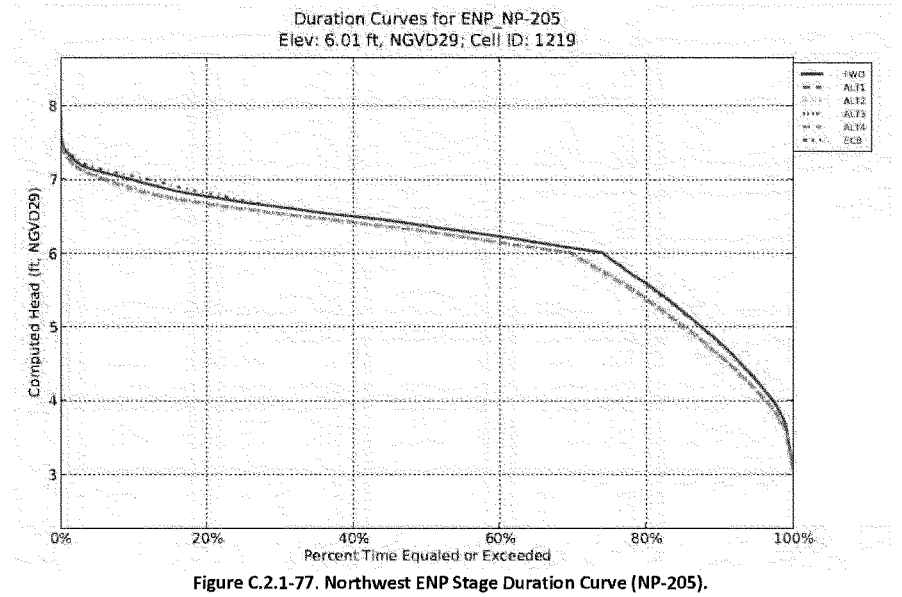


Figure C.2.1-77. Northwest ENP Stage Duration Curve (NP-205).

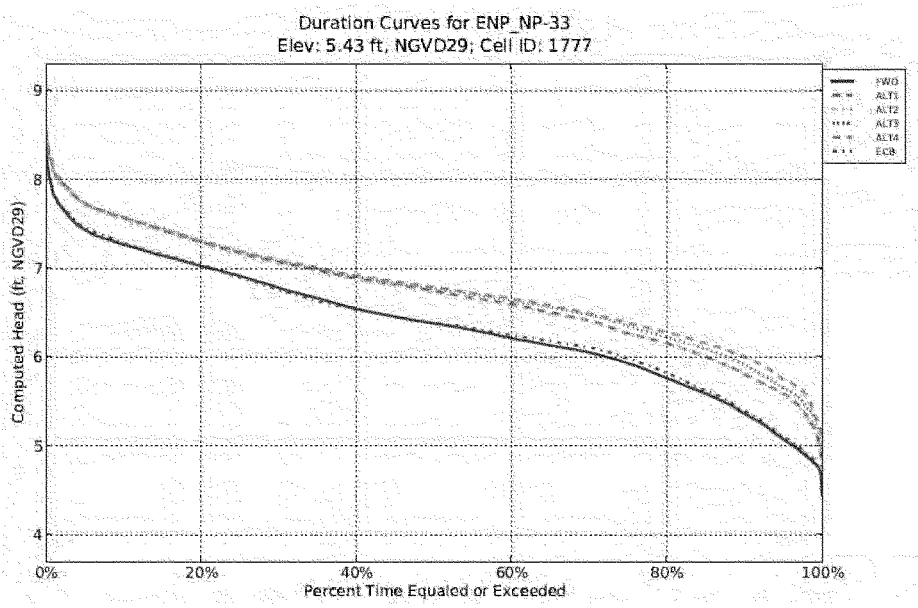


Figure C.2.1-78. Central ENP Stage Duration Curve.

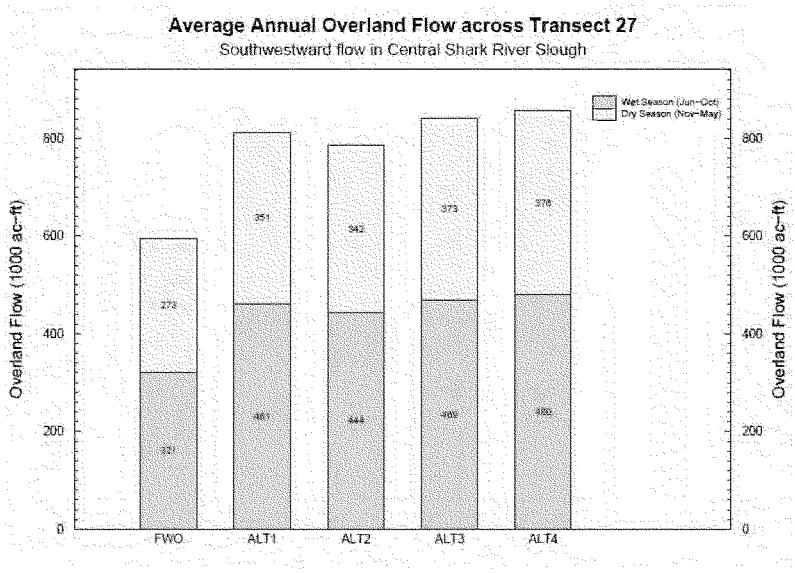


Figure C.2.1-79. Average Annual Overland Flow Transect for Central Shark River Slough.

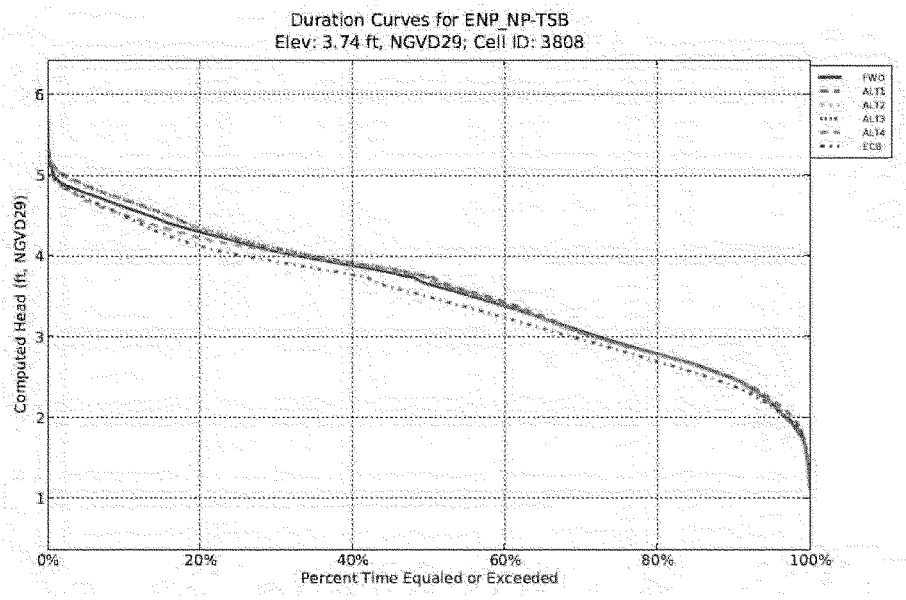


Figure C.2.1-80. ENP Taylor Slough Stage Duration Curve.

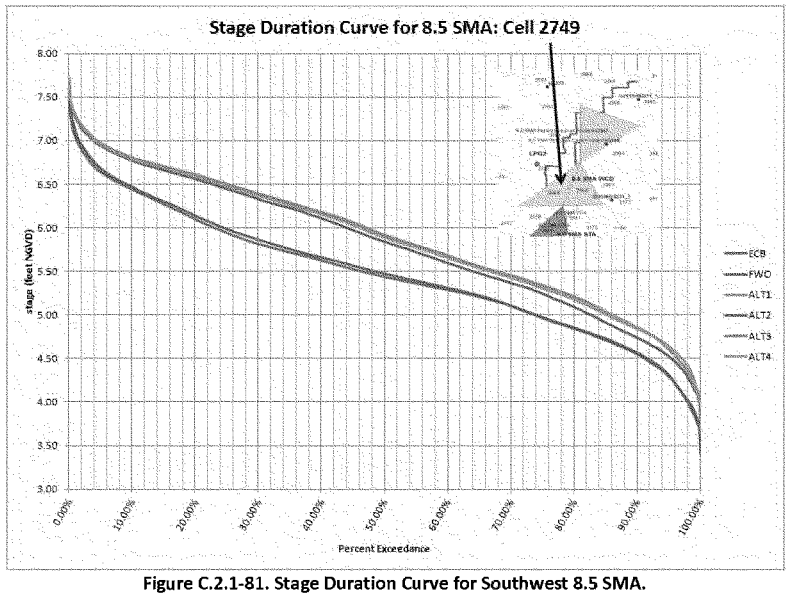


Figure C.2.1-81. Stage Duration Curve for Southwest 8.5 SMA.

C.2.1.8 Water Supply and Flood Control

Consistent with the Savings Clause requirements for CERP, each CERP project included in the CEPP FWO (Indian River Lagoon-South Project, Picayune Strand Restoration Project, Site 1 Impoundment Project, Biscayne Bay Coastal Wetlands Project, Broward County Water Preserve Areas Project, Caloosahatchee River (C-43) West Basin Storage Reservoir, C-111 Spreader Canal Western Project) must independently demonstrate in the respective PIRs that implementation of these CERP projects would not adversely impact the existing legal sources for water supply or the levels of service for flood protection. Operations protocols for the first and second generation CERP projects were modeled in the CEPP FWO consistent with the draft Project Operating Manuals, as documented in the respective PIRs. Operations and components of the previously listed CERP projects are retained in the CEPP final array of alternatives, and the inclusion of the components is therefore implicit to the analyses within this section.

To address the Savings Clause requirements for CERP, the CEPP draft PIR/EIS includes a detailed and comprehensive analysis of potential effects of the CEPP recommended plan, where applicable, to existing legal sources for water supply and/or the levels of service for flood protection (refer to Annex B for the complete analysis and to Section 6.8 of the main report for summary information). The general hydrologic overview of water supply and flood control performance of the action alternatives in this section is separate and distinct from the content of the recommended plan Savings Clause analysis contained in Annex B and **Section 6.8**. Areas within the CEPP project area that are not specifically discussed in this section may be presumed to have insignificant impacts to water supply or flood control.

C.2.1.8.1 Lake Okeechobee

Based on the action alternative modeling, compared to the FWO, the frequency of water restrictions enacted by the SFWMD Governing Board due to Lake Okeechobee falling below the Water Shortage Trigger line as defined by LOWSM is projected to slightly decrease for the CEPP action alternatives: one fewer year with three or more months with restrictions for LECSA 1 (note: two additional years with restrictions, compared to the ECB); no change in the number of years with three or more months with restrictions for LECSA 2 (note: one fewer year with restrictions, compared to the ECB); and two fewer years with three or more months with restrictions for LECSA 3 (note: one additional year with restrictions, compared to the ECB).

Lake Okeechobee operational assumptions applied consistently for the final array modeling (note: a single RSM-BN simulation was completed for the CEPP action alternatives) include changes to the decision tree outcome maximum allowable discharges dependant on Lake Okeechobee inflow forecasts, time of year (wet season or dry season), stage level (regulation zone), and/or stage trends (receding or ascending). The changes are all assumed to occur within the flexibility of LORS 2008 (Regulation Schedule zones unchanged), for the purpose of increasing CEPP potential benefits. Details pertaining to the proposed CEPP operations are separately addressed in the draft Preliminary Operations Manual (refer to **Annex C**).

Based on the CEPP alternative modeling assumptions and the resulting moderate stage increase within Lake Okeechobee, the average annual percentage of water supply demand not met is projected to decrease for the EAA and the remainder of the LOSA (**Figure C.2.1-82**). For the eight years with the largest water supply cutbacks within the LOSA, the water supply cutback percentage is reduced for seven of the eight years and increased for one of the eight years (1981), compared to the FWO (**Figure C.2.1-83**).

Lake Okeechobee stage duration curves for the RSM-BN model representation of the CEPP ECB (LORS 2008), CEPP FWO (LORS 2008, plus additional CERP and non-CERP projects), and the CEPP final array of action alternatives (LORS 2008, additional CERP and non-CERP projects, and prescribed operational flexibility) are shown in **Figure C.2.1-84**. A single RSM-BN simulation was completed for all of the CEPP components north of the red line for the final array of alternative. The CEPP action alternatives indicate a slight stage increase of 0.1-0.2 feet for the upper 40% of the stage duration curve. Peak stages for the CEPP baselines and the CEPP final array of alternatives are summarized as follows: 17.54 feet NGVD for the ECB; 17.50 feet NGVD for the FWO; and 17.64 for the CEPP Alts 1 through 4. The CEPP baselines and CEPP action alternatives all show simulated stages above 17.25 feet NGVD: 18 days for the ECB; 9 days for the FWO; and 23 days for CEPP Alts 1 through 4 (note: 14,975 days in the RSM-BN 41-year period of simulation). The LORS 2008 EIS assessment recognized that minimizing the frequency of exceedance of the 17.25 feet elevation offers additional protection for public safety and the HHD, for the condition prior to completion of the current approved and planned HHD remediation measures, and this criterion was evaluated as a LORS project performance measure. Extreme high lake stages have also been documented to adversely impact the plant and animal communities, through processes which include the following: physical uprooting of emergent and submerged plants; reduced light levels in the water column due to increased suspended sediment; and littoral zone exposure to increased nutrient levels from the water column. The number of days with stages above 16 feet NGVD is increased from 696 to 1096 during the 1965-2005 period of simulation.

Following completion of the HHD remediation of Reaches 1, 2, and 3, the degree to which higher maximum lake stages and increased frequency and duration of high lake stages would be accepted, if at all, will be contingent on the conclusions identified in the USACE 2014 Dam Safety Modification Report (DSMR) for the Herbert Hoover Dike (HHD). Any changes to the Lake Okeechobee Regulation Schedule would be analyzed and coordinated with the public through the NEPA process.

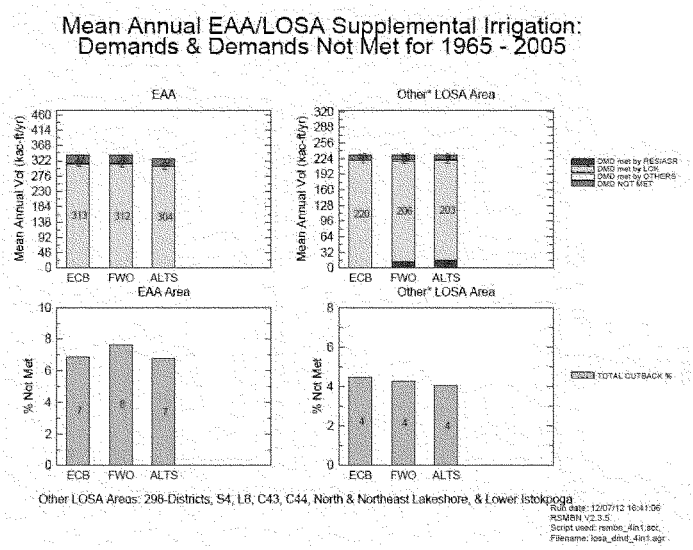


Figure C.2.1-82. EAA and LOSA Water Supply Performance.

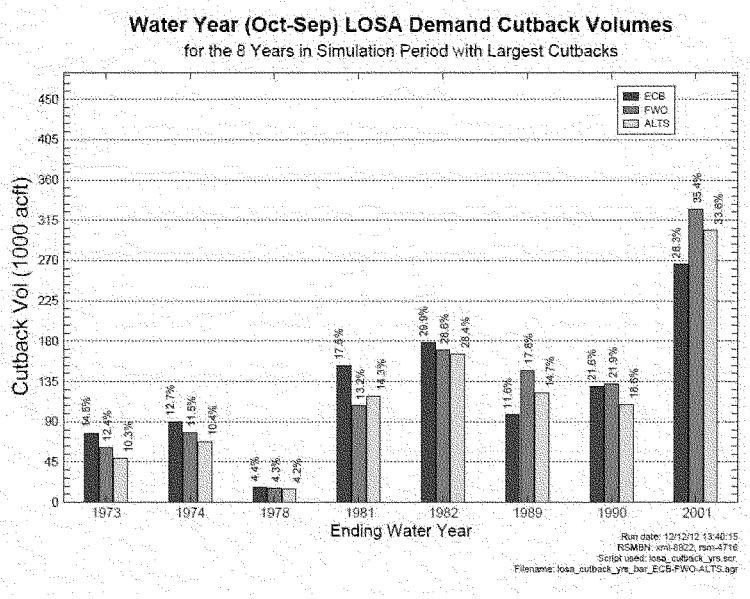


Figure C.2.1-83. LOSA Water Supply Performance for the Eight Largest Cutback Years.

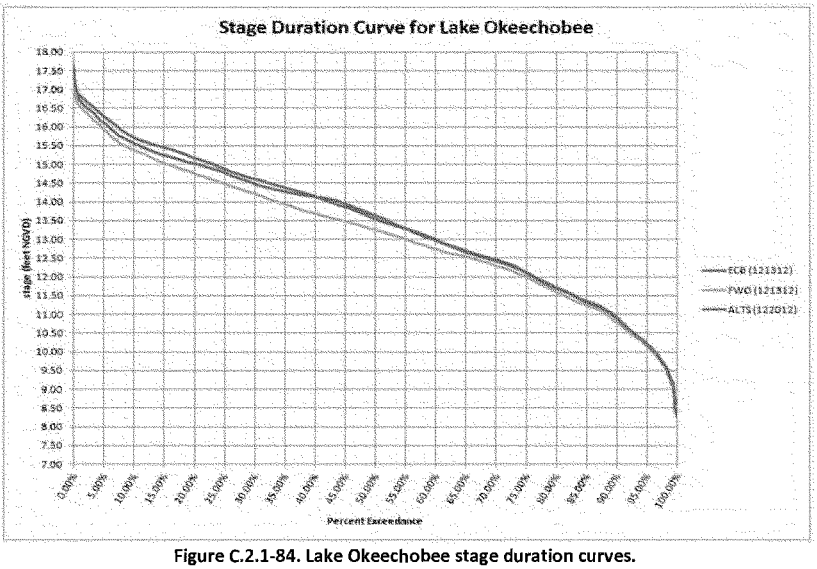


Figure C.2.1-84. Lake Okeechobee stage duration curves.

C.2.1.8.2 Seminole Tribe of Florida

Based on CEPP alternative modeling assumptions regarding Lake Okeechobee operational flexibility and the resulting moderate stage increase within Lake Okeechobee, the percentage of water supply demand not met for the Brighton Reservation is shown to slightly decrease by 0.4% compared to the FWO (**Figure C.2.1-85**) (note: demand not met is also 0.2% lower than the ECB). The percentage of water supply demand not met for the Big Cypress Reservation is shown to be slightly reduced by 0.2% (**Figure C.2.1-86**) (note: demand not met is also 1.0% lower than the ECB). The Seminole Tribe of Florida has surface water entitlement rights pursuant to the 1987 Water Rights Compact and subsequent entitlement provisions executed between the Seminole Tribe of Florida, the State of Florida, and the SFWMD. Impacts are not expected for the CEPP action alternatives based on the hydrologic modeling.

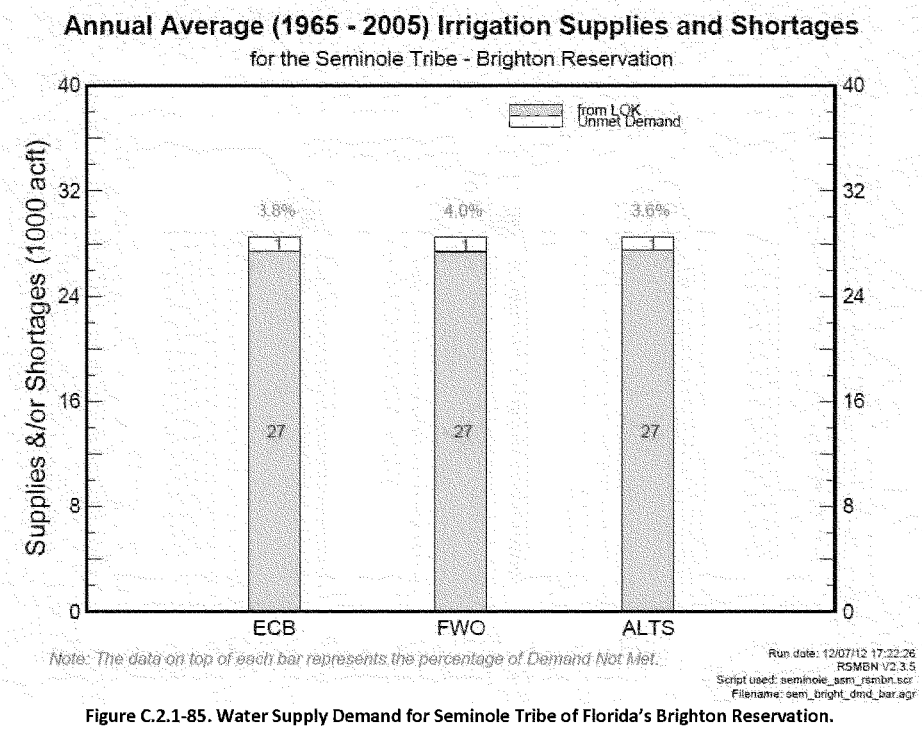


Figure C.2.1-85. Water Supply Demand for Seminole Tribe of Florida's Brighton Reservation.

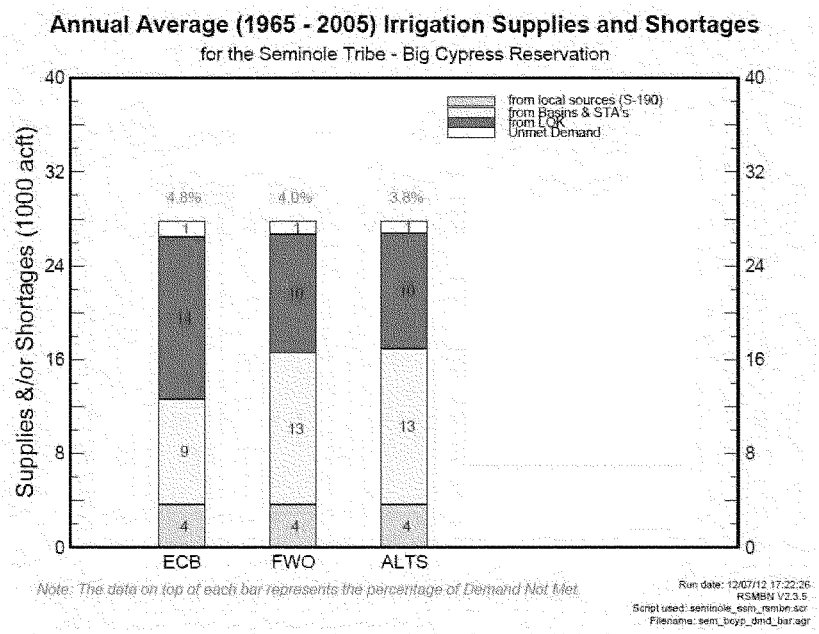


Figure C.2.1-86. Water Supply Demand for Seminole Tribe of Florida's Big Cypress Reservation.

C.2.1.8.3 Lower East Coast Service Areas

Based on the alternative modeling, compared to the FWO, the frequency of water restrictions enacted by the SFWMD Governing Board due to Lake Okeechobee falling below the Water Shortage Trigger line as defined by LOWSM is projected to slightly decrease for the CEPP action alternatives: one fewer year with three or more months with restrictions for LECSA 1 (note: two additional years with restrictions, compared to the ECB); no change in the number of years with three or more months with restrictions for LECSA 2 (note: one fewer year with restrictions, compared to the ECB); and two fewer years with three or more months with restrictions for LECSA 3 (note: one additional year with restrictions, compared to the ECB).

The CEPP modeling for Alts 1 though 4 also indicates no significant reductions to regional groundwater stages during dry conditions (assumed as a surrogate for water supply conditions for this discussion) for most portions within the LECSA, as compared to the CEPP FWO condition. No significant changes were indicated within LECSA 1, LECSA 2, and LECSA 3 that were prevalent through normal to dry hydrologic conditions, although some reduced stages were indicated during the driest 5-10% of hydrologic conditions for areas east of WCA 2A and WCA 2B (monitoring gages G2031, G2033, and G2032). Lowered regional groundwater stages during dry conditions that were apparent for the FWO when compared to the ECB are not further exacerbated by the CEPP action alternatives.

For the action alternatives, L-30 Canal stages (north of S-335) are generally observed to increase for normal to extreme dry conditions (**Figure C.2.1-87**): stages are moderately increased by 0.2-0.4 feet for Alt 1; significantly increased by 0.3-1.0 feet for Alt 2; significantly increased by 0.3-0.7 feet for Alt 3; and

slightly increased by 0.1-0.2 feet for Alt 4. L-30 Canal stages are highly correlated to hydrologic conditions within central and eastern WCA 3B. L-31N Canal stages (north of G-211) are increased by 0.3-0.5 during dry conditions for Alt 1; however, L-31N Canal stages are generally decreased under normal to dry conditions for the other Alternatives: Alternative 2 stages are lowered by 0.2-0.3 feet for normal to dry conditions; Alt 3 stages are lowered by 0.2-0.3 feet for wet, normal, and dry conditions, with a 0.1-0.2 increase in extreme dry conditions; and Alt 4 stages are lowered by 0.2-0.3 feet for wet, normal, dry, and extreme dry conditions (**Figure C.2.1-88**). No significant stage reductions within the C-111 Canal (between S-176 and S-18C) are indicated during normal to dry hydrologic conditions that would affect water supply deliveries (**Figure C.2.1-89**).

The modeling of Alts 1 through 4 indicates no significant increases to regional groundwater stages during wet conditions which would impact the levels of service for flood control within the LECSA, as compared to the CEPP FWO condition. No significant changes were indicated within LECSA 1, LECSA 2, and significant reductions were observed for portions of LECSA 3. The L-30 Canal stages (north of S-335) indicate a general moderate reduction of 0.2 feet to flood control stages within the wettest 10% of hydrologic conditions (**Figure C.2.1-87**), and the L-31N Canal stages (north of G-211) indicate a significant (up to 1.0 feet) reduction to flood control stages within the wettest 5% of hydrologic conditions (**Figure C.2.1-88**).

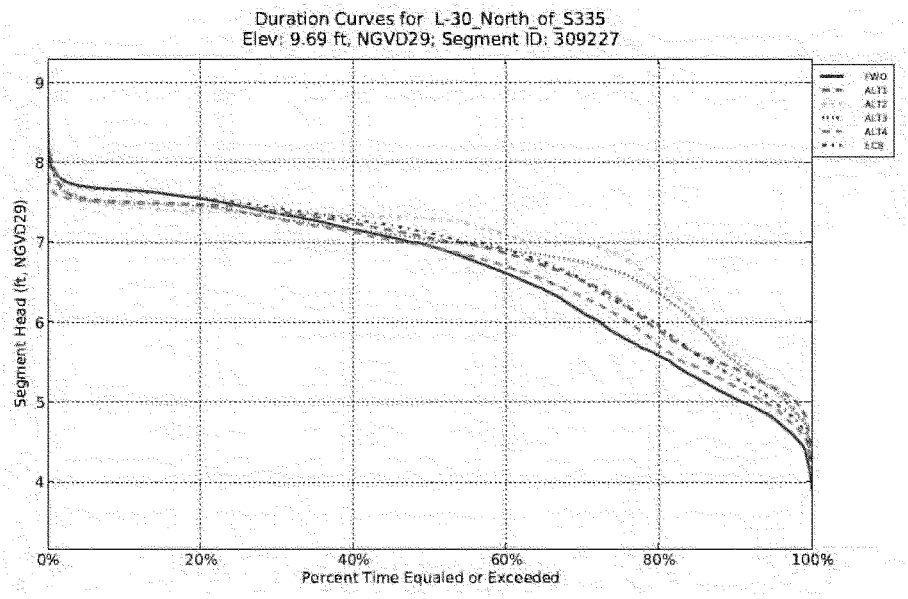


Figure C.2.1-87. Stage Duration Curve for L-30 Canal in LECSA 3.

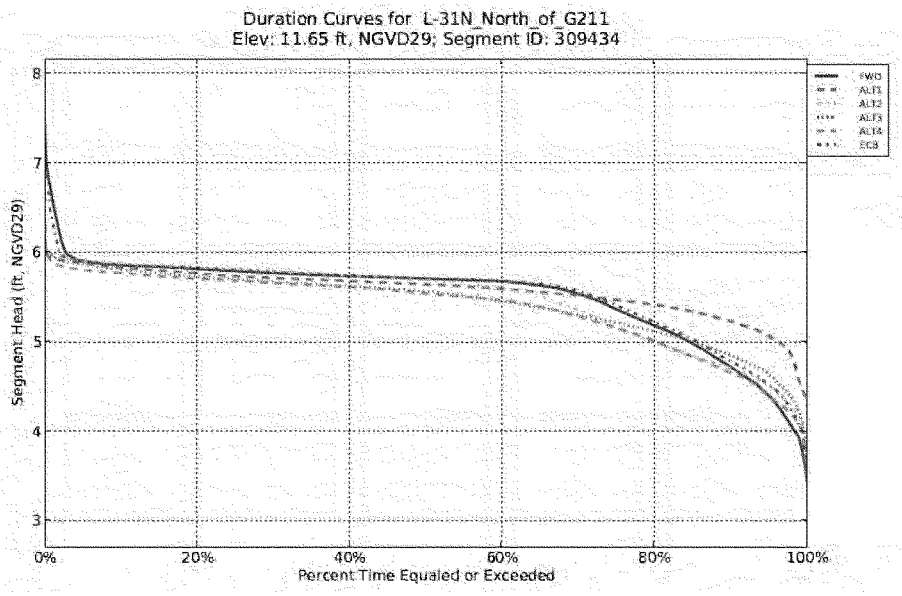


Figure C.2.1-88. Stage Duration Curve for L-31N Canal in LECSA 3.

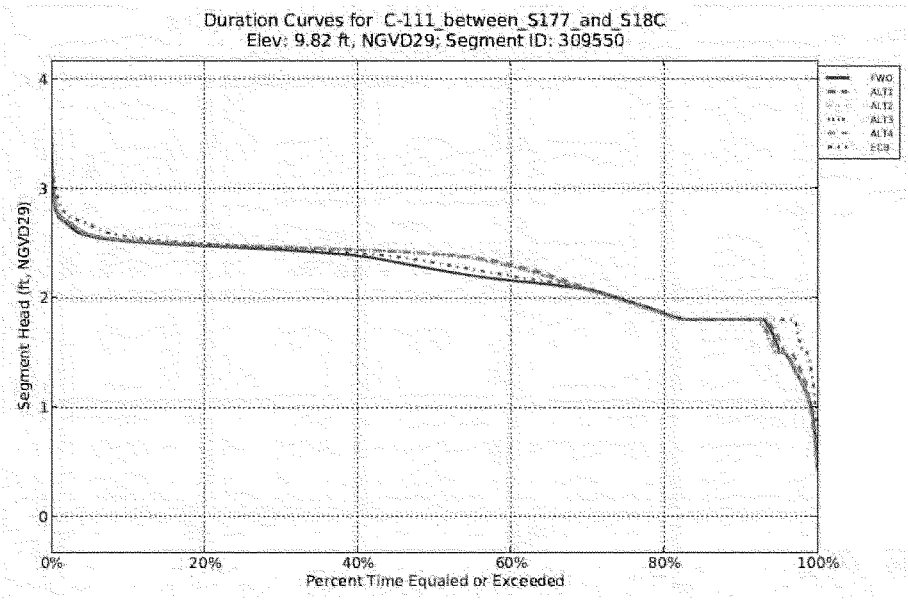


Figure C.2.1-89. Stage Duration Curve for C-111 Canal in LECSA 3

C.2.1.9 Water Quality

C.2.1.9.1 Lake Okeechobee

Relative to the FWO project, the with-project action alternatives will likely result in some improvement in Lake Okeechobee water quality as a result of reduced extreme lake stage events. However, the expected improvement in Lake Okeechobee water quality will likely not be very significant since nutrient loading conditions are not expected to differ significantly between the with- and without-project conditions. All with-project action alternatives are expected to result in the same water quality conditions since lake operations are nearly the same for all of them. As discussed in the existing conditions section for Lake Okeechobee, there is an existing TMDL for phosphorus. This TMDL requires a reduction in annual phosphorus loading from more than 500 metric tons per year to 140 metric tons per year. The average annual S-308 backflow phosphorus load is 2.6 metric tons per year under the existing condition and 4.6 metric tons/yr under the with-project condition. . The increase of 2 metric tons per year amounts to less than 1.5 percent of the phosphorus TMDL target of 140 metric tons/yr. The allocation of TMDL phosphorus loads will be addressed through revisions to the Lake Okeechobee Basin Management Action Plan. Specifically, the FDEP is in the process of developing a BMAP for Lake Okeechobee pursuant to Section 403.067, Florida Statutes. Potential water quality issues associated with S-308 loads will be addressed as part of the BMAP.

C.2.1.9.2 Northern Estuaries

Caloosahatchee: Improved salinity conditions within this estuary as a result of a reduction in the number of high flow events and a reduction in the number of extreme low flow events as characterized by flows through the S-79 structure. Nutrient and dissolved oxygen conditions should improve during the wet season within the estuary given the reduction in high flow events. The frequency of dry season algal events within the upper estuary may change as a result of increased dry season flows through the S-79 structure during the late spring.

St. Lucie Estuary: Improved salinity conditions within this estuary as a result of a reduction in the number of high flow as characterized by flows through the S-80 structure. Nutrient and dissolved oxygen conditions should improve during the wet season within the estuary given the reduction in high flow events. The number of months of flow less than 300 cfs increases which may alter the frequency of algal blooms during the later part of the dry season.

C.2.1.9.3 EAA

Relative to the FWO, the EAA nutrient loads should decrease somewhat due to the cessation of agricultural practices from the A-2 lands as well as other lands that will no longer be farmed in when CEPP is implemented. The with-project action alternatives all include the A-2 FEB integrated into the A-1 FEB and the same volume of additional Lake Okeechobee water distributed south of the EAA. Dynamic Model for Stormwater Treatment Areas (DMSTA) water quality modeling indicates that the with-project action alternatives will meet the 2012 Water Quality-based Effluent Limits (WQBEL). Construction of the A-2 FEB may cause a short-term release of methylated mercury; however, monitoring during the start of phase will minimize potential adverse impact to downstream biota.

C.2.1.9.4 Greater Everglades

C.2.1.9.4.1 WCA 1, WCA 2

Water quality conditions for WCA 1 are not expected to be significantly changed by any of the With-Project Action alternatives since none of them include features that influence flows and treatment within the eastern flow path. Nutrient and sulfate loading conditions in WCA 2 should improve somewhat given the reduction in hydrologic load sent to this water conservation area. Reduced sulfate loading could somewhat alter the areas where mercury methylation is problematic within WCA 2.

C.2.1.9.4.2 WCA 3A

Alternative 1 vs. FWO

Nutrient loading into the northern portion of WCA 3A is expected to increase relative to the FWO condition as a direct result of the increase in hydrologic loading; however, relative to the existing condition, nutrient loads into WCA-3A will decrease by approximately 30 and 25 percent for FWO and the Alt 1, respectively. Sulfate concentrations into the northern portion of WCA 3A are expected to decrease with Alt 1 as a result of the additional dilution of EAA runoff with Lake Okeechobee discharges which have sulfate concentrations roughly half that of the EAA runoff; however, the increase in flow will result in a slight increase (approximately 3 percent) in total sulfate load into the WCA 3A.

Figure C.2.1-90 shows the average annual flow across three transects in WCA 3A. Relative to the FWO condition, Alt 1 shows significant increases in flow crossing the northern and southern transects as a result of backfilling of a portion of the Miami Canal. Increased uptake in the northern portion of WCA 3A will likely result in reduced TP concentrations at the southern end of this WCA as compared with the FWO condition which has significant canal flows that provide less nutrient uptake than sheetflow across the marsh. It is likely that northern portions of the WCA 3A marsh that are adjacent and south of the L-4, and L-5 canals will experience higher TP loads as compared to the FWO. The effects of the with-project action alternatives on WCA 3A compliance with the four-part TP criterion defined in Section 62-302.540, F.A.C. are expected to be similar. A detailed discussion of phosphorus impacts to WCA3A due to CEPP are found in **Annex F**.

The methylmercury cycle is very complex with many factors affecting bioaccumulation in fish. Changes in hydrology can impact the formation of methylmercury. For instance, Alt 1 will reduce dryout/rewetting cycles in northern WCA 3A which will reduce sulfate and Hg remobilization due to soil oxidation. Project related changes to the timing, distribution, and loading of sulfate in WCA 3A will likely alter the locations where methylated mercury is found at high concentrations in the water column. This is illustrated in **Figure C.2.1-91** from the 2013 SFER report which projects the impact to mosquitofish mercury body burden of reducing by 50 to 100 percent the agriculturally sourced sulfate discharged into the Everglades Protection Area. This figure shows that significant decreases in sulfate loading would both increase and decrease mosquitofish mercury concentrations in WCA 3A depending upon location. A 100 percent reduction in non-marine sulfate exported from the EAA is projected to result in an overall reduction in average water column sulfate concentrations within the Everglades Protection Area from 2.4 mg/L to 0.78 mg/L; however, the average mosquitofish mercury concentration is estimated to be reduced from 85.7 ng/g to 80.0 ng/g which is a relatively insignificant change in proportion to the reduction in sulfate. Though these projections are for decreases in sulfate rather than increased sulfate loading, they are indicative of the relative insensitivity of mosquitofish methylmercury bioaccumulation to relatively small changes (<10 percent increase) in sulfate loading as contemplated with Alt 1.

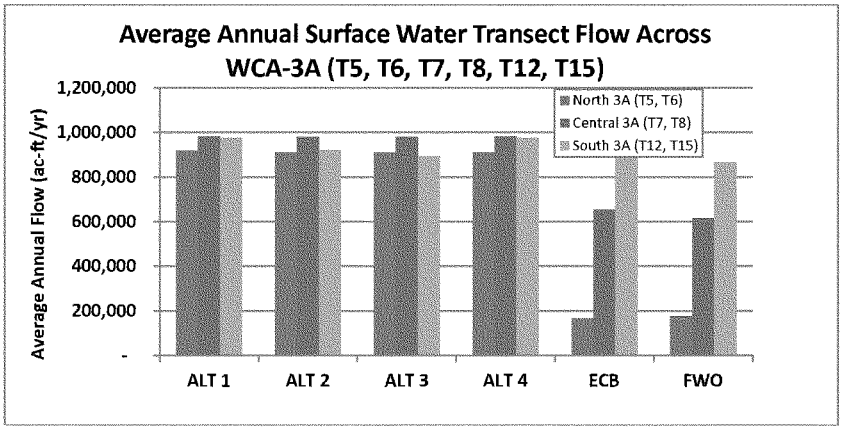


Figure C.2.1-90. Average Annual Surface Water Transect Flows for WCA 3A.

Given the complexity of the methylmercury cycle, It is not possible to predict with certainty the effect of CEPP related changes to sulfate timing, distribution, and loading within WCA 3A. It is likely that some areas of WCA-3A will see higher mosquitofish mercury concentrations while other areas will see lower mosquitofish mercury concentrations. Give the reduction in atmospheric mercury deposition over the last 15 years which is thought to be the cause of the reduction in bioaccumulated mercury observed in fish over this time period, it is likely that future methylation and bioaccumulation of mercury that occurs after implementation of Alt 1 will not exceed the peak concentrations seen 15 or so years ago unless atmospheric mercury loading increases.



Figure C.2.1-91. Predicted changes in *Gambusia* Hg concentrations in response to 50 and 100 percent reductions in excess (non-marine) sulfate exported from the EAA (left and right, respectively) using R-EMAP Cycles 6 and 7 data. (from SFWMD, 2012)

Alternative 2 vs. FWO

Alternative 2 performs similarly to Alt 1 in WCA 3A for nutrients, sulfate, and other water quality constituents.

Alternative 3 vs. FWO

Alternative 3 performs similarly to Alt 1 in WCA 3A for nutrients, sulfate, and other water quality constituents.

Alternative 4 vs. FWO

For WCA 3A, this alternative performs very similar to Alt 1 for nutrients, sulfate, and other water quality constituents.

C.2.1.9.4.3 WCA 3B

Alternative 1 vs. FWO

Additional water flow into WC 3B will result from the breaches of the L-67A and L-67C levees. Relative to the FWO condition, flows through these breaches will be composed of more water that passes through the northern WCA 3A marsh and less water from the Miami Canal and the S-9 basin since these flows are reduced by approximately 50% at S-151 and 9% from S-9/S-9A pumps. Increased hydration of WCA 3B will reduce the risk for severe dry down and thus reduce fire risk relative to FWO. Water quality

degradation such as the release of TP into the water column and increased Methylmercury (MeHg) in the water column associated with fire events and their aftermath will be reduced. Additional flow into WCA 3B will increase nutrient loads relative to the FWO condition. **Annex F** includes a detailed discussion of the impact of CEPP on phosphorus within WCA 3B.

Like WCA 3A, sulfate loads are likely to increase in WCA-3B due to increased flows into this area relative to the FWO condition. Less frequent dryout/rewetting cycles within this area should reduce soil oxidation and the resulting recycling of sulfate and mercury back into the water column. The effects of additional sulfate on water column methylmercury concentrations and total mercury body burden in fish and birds in WCA-3B cannot be predicted with certainty. In light of this uncertainty, there is no reason to predict that the CEPP project will result in bioaccumulation that exceeds historic mercury concentration maximums unless atmospheric mercury deposition increases over present rates. The recent downward trends in measured water and tissue mercury concentrations in this area are encouraging.

Alternative 2 vs. FWO
This alternative's water quality performance is expected to be very similar to that provided by Alt 1 in WCA 3B.

Alternative 3 vs. FWO
This alternative's water quality performance is expected to be very similar to that provided by Alt 1 in WCA 3B.

Alternative 4 vs. FWO
This alternative's water quality performance is expected to be very similar to that provided by Alt 1 in WCA 3B.

C.2.1.9.4.4 Everglades National Park

C.2.1.9.4.4.1 Shark River Slough

Alternative 1 vs. FWO
Water entering Shark River Slough (SRS) from WCA 3 is likely to have lower concentrations of TP as compared with the FWO condition due to the backfilling of the Miami Canal which will result in more water passing through the marsh areas and less water flowing directly from upstream canal sources. Additional discussion of the effect of the CEPP project on total phosphorus concentrations in ENP is provided in **Annex F**.

Fish mercury concentrations within ENP have not decreased as much as that observed in WCA 3. The reasons for continued higher concentrations of bioaccumulated mercury in ENP fish are not well understood at this time due to the complexity of processes involved. The range of sulfate concentrations that maximize methylmercury formation in ENP may differ from that in the water conservation areas. The effects that small changes in sulfate in ENP would have on fish mercury are difficult to predict.

Sulfate loading into ENP under the Alt 1 condition is likely to decrease somewhat relative to the FWO condition primarily because most of the flows into northern ENP will have been routed through the WCA 3 marsh which is likely to remove more sulfate than the additional sulfate provided by the increased flow from Alt 1. The additional flow will increase stages within Shark River Slough by an average of 0.5 ft

which should significantly reduce areas that are subject to dryout and rewetting. Reduced dryout and rewetting will reduce the recycling of sulfate and mercury that exacerbates mercury bioaccumulation. The effects of Alt 1 on formation and bioaccumulation of methylmercury cannot be predicted with certainty since the mechanisms that affect mercury methylation rates in ENP are not fully understood at this time. However, if sulfate loads do not increase with Alt 1 and the additional flow reduces dryout/rewetting cycles, it is likely that future with-project mercury methylation conditions will not exceed the peak concentrations observed in ENP in 1999 unless atmospheric deposition of mercury increases in the future. Continued monitoring and scientific investigation of mercury within the Everglades Protection Area will provide more certainty regarding potential project impacts well before the additional flows from Alt 1 are realized.

Alternative 2 vs. FWO
This alternative's water quality performance is expected to be very similar to that provided by Alt 1 in WCA 3B.

Alternative 3 vs. FWO
This alternative's water quality performance is expected to be very similar to that provided by Alt 1 in WCA 3B.

Alternative 4 vs. FWO
This alternative's water quality performance is expected to be very similar to that provided by Alt 1 in WCA 3B.

C.2.1.10 Air Quality

Direct emissions from the proposed construction of the CEPP project features would be confined to exhaust emissions of labor transport equipment, and construction equipment (dump trucks, excavators, graders, bulldozers, etc.). Clean Air Act pollutants considered in this air quality assessment are SO_x; volatile organic compounds (VOCs); nitrogen oxides (NOx), CO, PM10, and PM2.5. Green house gas emissions are also considered. Volatile organic compounds, sulfur oxides, and nitrogen oxides are important since they are precursors to ozone generation. These criteria pollutants are generated by the construction and operational activities associated with the proposed action alternatives.

In Lake Okeechobee and the Northern Estuaries, population growth in the area is expected in the FWO condition relative to existing conditions baseline, this is an increase in air pollution. However, air quality compliance is expected. All action alternatives are expected to have no change relative to FWO conditions in Lake Okeechobee and the Northern Estuaries. In the Everglades Agricultural Area (EAA) no change in compliance with air quality standards is expected in the FWO compared to the baseline condition. For Alts 1-4, no change in air quality compliance is expected. Reduction in farming equipment use on A-2 FEB lands in FWO condition will be offset by increase in air pollutants from new pump stations. Particulate loading should be reduced since sugar cane cultivation will no longer done on FEB land and thus annual burning during harvesting will no longer be done. In the Greater Everglades, increased Lower East Coast (LEC) development in the FWO will result in air quality degradation relative to baseline conditions. Enforcement of the Clean Air Act should limit impacts. For Alts 1-4 a decrease in drying event severity relative to FWO condition should result in reduced fire incidence within wetlands which should improve air quality. No changes in air quality are expected in the FWO and Alts 1-4 in the Southern Estuaries. A detailed analysis of Air Quality impacts has been prepared for the recommended plan in **Section 6** and **Appendix C.2.2.10.** The air quality analysis done for the recommended plan is applicable for Alts 1-4 given their similarities to Alt 4R.

C.2.1.11 Hazardous, Toxic and Radioactive Waste

The FWO and with-project alternative conditions will have similar hazardous, toxic and radioactive waste (HTRW) conditions in the future with the exception of the lands used for the A-2 FEB. (See **Appendix C.1** for the expanded HTRW assessment and **Annex H** for HTRW reports and correspondence.) Under the FWO condition, the A-2 FEB lands will likely continue to be farmed which will result in the additional application of agricultural pesticides in the cultivated portions of this property and the inadvertent release of petroleum and pesticides in operation and maintenance areas. During the construction of project features, is possible that undiscovered HTRW contamination will be found. Per EC 1165-2-132, the non-federal sponsor will be required to remediate these sites at their sole expense. There is also the potential for HTRW release associated with the operation of project pump stations; however, with modern facilities and best management practices, this presents a minor risk to the environment.

C.2.1.11.1 Residual Agricultural Chemicals

All of the with-project action alternatives include the use of the A-2 FEB lands. Soil sampling has shown that residual agricultural chemicals are in the cultivated soils on the A-2 FEB lands. A discussion of residual agricultural chemicals on the A-2 FEB lands is found in **Appendix C.2.2**.

C.2.1.12 Noise

For the action alternatives there would be minor short term and less than significant increases in noise during construction activities. All CEPP action alternatives include additional pump stations which would result in long-term, localized increases in noise. Since Alt 4 adds the fewest number of pump stations (two), it would have the least effect with Alt 3 that adds 5 additional pump stations having the greatest effect.

C.2.1.13 Aesthetics

Aesthetic effects refer generally to impacts on the visual qualities of the environment. Restoration of the south Florida ecosystem is expected to result in a healthier environment that would support vigorous plant communities, larger fish and aquatic animal populations, large numbers of wading birds, alligators, and sustainable populations of wide-ranging mammals, in a natural setting, in perpetuity. Viewing wildlife, wetlands and open, relatively pristine spaces are valued by people, as supported by tourism statistics for south Florida. During construction of all features there will be a temporary short-term significant impact to aesthetic values in the construction areas. All action alternatives show a significant increase in aesthetic value over the FWO due to restoration of hydropatterns and sheetflow throughout the project area and provide a minor beneficial effect. The restoration of sheetflow provides additional habitat for native plants and animals and opportunities for wildlife viewing.

There would be negligible and less than significant effects due to CEPP in Lake Okeechobee. In the Northern Estuaries, the action alternatives would increase the aesthetic value due to decreased high flow events and provide minor beneficial effects. Reductions in high volume discharges to the estuaries would result in lower suspended solids, increased water clarity and the correct salinity envelope that maintain healthy SAV beds. These benefits could also and lead to an increase in wildlife viewing opportunities (Orth et al., 2006). Within the EAA, the existing aesthetic character of the A-2 footprint is similar to the EAA as a whole; the landscape is flat and has a predominantly uniform and organized appearance. For the action alternatives, wetland vegetation is anticipated to colonize the A-2 FEB increasing wildlife utilization and opportunities for wildlife viewing within the area, providing a significant and major beneficial effect. In the southern estuaries, the action alternatives provide minor beneficial effects would

increase the aesthetic value due to an increase in native plants and animals due to increased flows in Florida Bay providing an increase in potential wildlife viewing as well as providing a potential for the reduction in red tide occurrences.

Within the Greater Everglades, Alt 1 would produce minor increases in aesthetic value due to the removal of the L-4 levee by providing a more natural landscape view. Alternatives 3 and 4 had a greater potential negative effect on aesthetics as compared with Alts 1, 2 and FWO due to the addition of 2 pump stations along the L-29 levee in Alt 3 and the construction of a new levee (Blue Shanty levee) in Alt 4. For all action alternatives there would be temporary, short-term, localized effects to aesthetics during construction of all features. All action alternatives show a significant increase in aesthetic value over the FWO due to restoration of hydropatterns and sheetflow throughout the project area and provide minor beneficial effects. The restoration of sheetflow provides additional habitat for native plants and animals and increased opportunities for wildlife viewing. Restoration of flows within Florida Bay and the southwestern coastal estuaries that reduce extreme salinity ranges improves habitat within these regions, increase potential opportunities for wildlife viewing. All action alternatives include backfilling portions of the Miami Canal, thereby improving aesthetics due to removal of this unnatural landscape feature, providing minor beneficial effects.

For Alt 2, the removal of the L-4 levee and the construction of a spreader canal to the east of S-8 would provide a moderate increase in aesthetic value by providing a more natural landscape view over a larger area than Alt 1, however there would be an additional minor affect due to the addition of a pump station on the L-5 canal. The Miami Canal backfill for Alt 2 includes an additional 1.5 miles at the very northern portion adding a slight increase in aesthetic value as compared with Alt 1. There would be a moderate negative impact with the addition of a pump station on L-31N and a partial depth seepage barrier by adding man-made features in the natural landscape. The complete degradation of L-67 Extension levee provides a long-term increase in aesthetics due to the restoration of sheetflow increased native plants and animals and viewing potential.

The aesthetic effects of Alt 3 are the same as those for Alt 2 with respect to removal of L-4 and construction of a spreader canal, backfilling of the Miami Canal and the complete degradation of the L-67 Extension levee. Alternative 3 has a major negative aesthetic effect due to the addition of 2 pumps on L-29. Along the L-31N, Alt 3 would have a minor aesthetic effect due to a full and partial seepage barrier. The aesthetic effects of Alt 4 are the same as Alts 2 and 3 for L-4 removal and construction of a spreader canal, the backfilling of the Miami Canal and the complete degradation of L-67 Extension levee. The construction of the Blue Shanty Levee (~8 mile levee) in WCA 3B has a major negative effect on aesthetic value due to the addition of a levee within a wetland, however, it creates a flowway to the west that provides wildlife viewing opportunities and water flowing under Tamiami Trail. The seepage barrier in Alt 4 provides a significant and moderate negative effect to the aesthetics.

C.2.1.14 Socioeconomics

Effects are provided in the main report in **Section 5.1.5**.

C.2.1.15 Recreation

In Lake Okeechobee and the Northern Estuaries, FWO and Alts 1-4 have a negligible and less than significant effect on current recreation opportunities. . There will be no impacts to recreational navigation with this project. Alternatives 1-4 may provide enhanced fishing opportunities due to better salinity conditions in the Caloosahatchee and St. Lucie Estuaries. Reductions in high flows to the Northern Estuaries would enhance fish populations and subsequently improve related recreational opportunities such

as fishing, boating and kayaking. In the Everglades Agricultural Area (EAA), currently no recreation exists on the project site so any effects would be positive for public access meeting the identified needs according to Florida's Statewide Comprehensive Outdoor Recreation Plan (SCORP) for all action alternatives.

In the Greater Everglades, in the FWO condition recreational fishing would be affected little if at all. Hiking, biking and camping will not be affected directly. Any changes in recreation would be due to degraded quality of wetlands and the aesthetic values that could decrease as wildlife viewing and nature study would be degraded. In the Greater Everglades Alt 1 affects to recreation will be negative or positive depending on the activity and location. Recreational fishing by boat will have a significant and major adverse effect by back filling the Miami canal. This affects 13.5 of the 33 miles of the Miami canal in WCA 3. Bank Fishing opportunities would have a minor beneficial effect by addition of access points around proposed structures. Alternative 1 has the least negative effect on current Northern WCA 3A terrestrial mammal hunting opportunities. Terrestrial mammal hunting (deer, hog, rabbit, etc.) could have a short-term significant, adverse and unavoidable effect by increased hydration in areas that have been drier. In the long term if not better hydration peat loss to oxidation and fire would degrade current habitat further. Waterfowl hunting should improve with better hydration throughout the greater everglades during the early part of the dry season. This is good for bird watching as well. Improved access and designation of blue and greenway trails will be positive minor beneficial effect. Alternative 2 has similar effects to Alt 1 however; terrestrial mammal hunting (deer, hog, rabbit, etc.) could be affected negatively in the short term by increased hydration in areas that have been drier. In the long term if not better hydration peat loss to oxidation and fire would degrade current habitat further. Waterfowl hunting should improve with better hydration throughout the Greater Everglades during the early part of the dry season. This is good for bird watching as well. Improved access and designation of blue and greenway trails will be positive. Alternative 3 effects are similar to Alt 2. Alternative 4 effects to recreation will be negative or positive depending on the activity and location. Alternative 4's Blue Shanty Levee will bisect L67C. Recreational fishing by prop boat to the northern end of L67C canal would continue to be available from a new public boat ramp located in the northern end of L67C at the S151, providing a minor beneficial effect. Also at the 5151 a new public boat ramp will allow access into the northern 5 miles of the Miami Canal south of S151 not previously served by a public boat ramp. Bank fishing opportunities could be positively increased by addition of access points around proposed structures. Terrestrial mammal hunting (deer, hog, rabbit, etc.) could be affected negatively in the short term by increased hydration in areas that have been drier. In the long term if not better hydration peat loss to oxidation and fire would degrade current habitat further. Waterfowl hunting should improve with better hydration throughout the greater everglades during the early part of the dry season. This is good for bird watching as well. Improved access and designation of blue and greenway trails will be positive.

In the Southern Estuaries there is no effect on recreation with the FWO. For Alts 1-4 access to the Southern Estuaries would not change based on CEPP, however, impacts to existing quality of recreation can be impacted negatively or positively depending on location and changes to fish habitat as identified above for the Greater Everglades, however additional flows to Florida Bay are expected to provide enhanced fishing opportunities and a minor beneficial effect. A Recreation Plan is included in **Appendix F**.

C.2.1.16 Land Use

C.2.1.16.1 Wetlands and uplands

Much of the future development within the study area is expected to occur on lands that were formerly in agricultural use. For all action alternatives, publically owned lands are being utilized. **Table C.2.1-7** summarizes the impacts to wetlands for the final array of alternatives. All action alternatives show a significant and major beneficial effect with an increase in wetland/upland habitat over the FWO as well as an increase in wetland function. Alternative 3 provides the greatest increase in acreage with 675 acres followed by Alt 2 with 671 acres, Alt 4 with 650 acres and Alt 1 provides the least with 531 acres. There is only about 144 acres difference between all the action alternatives and these are estimates at this time until detailed design is completed. The differences stem from different project features (lengths of backfilling, gaps, number of structures, etc) as detailed below. While there are some minor adverse effects due to the construction of features, most notably the Blue Shanty Levee in WCA 3B, the construction of other features, the degradation of levees and the backfilling of canals reconnects and adds wetland acreage providing the needed topography for sheetflow to restore the natural system.

In addition to gains in wetlands, all action alternatives shift approximately 13,800 acres of agricultural land use with wetland soils to a higher quality wetland with the construction of the A-2 FEB. The A-2 FEB would alter the land use from agriculture to an FEB that includes wetland habitat. The degradation of the L-4 levee adds ~35 acres due to the reconnection of the wetlands in northwestern WCA 3A. The backfilling of the Miami Canal would provide an additional 469 acres of wetlands for Alts 2, 3 and 4 and an additional 417 acres of wetlands for Alt 1. The difference in acreages is due to leaving the northern 1.5 miles open along the Miami Canal in Alt 1. The backfilling of the Miami Canal would restore the wetland habitat and reestablish sheetflow in northern WCA 3. For all action alternatives spoil mounds on both sides of the Miami Canal from S-8 to S-339 would be removed and 22 spoil mounds (the highest priority/highest functioning Florida Fish and Wildlife Conservation Commission (FWC) enhanced spoil mounds) would be maintained while the others will be removed. In addition to the removal of the selected spoil mounds in order to promote sheetflow across the backfilled Miami Canal, additional mounds (1.5 feet above the marsh surface) would be created every mile from S-8 to Interstate 75 to prevent hydraulic channelization of flow and provide upland animal habitat. This would provide an additional 49 acres of upland habitat for Alts 2, 3 and 4 and an additional 45 acres of upland habitat for Alt 1. Alternative 1 has one less mound due to starting the backfilling of the Miami Canal 1.5 miles south of S-8. This additional upland habitat provides refuge for terrestrial mammals during periods of high water. These mounds also align with the historic ridge habitat and there is the possibility that the placement of the mounds would help reestablish the ridge and slough pattern in WCA 3A.

In southern WCA 3A and WCA 3B, several features increase wetland habitat while other features remove/impact wetland habitat while connecting WCA 3A to WCA 3B and ENP. The proposed L-67A culverts will have a slight negative impact to the wetland of 4.5 acres/gated culvert. Due to the different number of culverts proposed in each alternative, the impact varies per alternative. Alternative 3 has the greatest loss of wetlands of 18 acres due to 4 culverts along the L-67A. Alternatives 2 and 4 have 3 culverts and a loss of 13.5 acres and Alt 1 has 1 culvert, thus a loss of 4.5 acres. However, the culverts are critical to connecting WCA 3A and WCA 3B and in conjunction with the gated culverts in L-67A levee, there are 6,000 foot gaps in the L-67C levee that will increase wetland habitat. Each 6,000 foot gap will provide an additional 9 acres of wetland habitat. Alternatives 1 and 4 provide 9 additional acres of wetlands. Alternative 4 has only one 6,000 foot gap because the other two gated culverts are included in the Blue Shanty flow way discussed below. Alternative 2 provides 27 acres of wetlands from its three gaps and Alt 3 provides 36 acres for its four gaps. The degradation of approximately six miles of the L-67C in Alt 4 provides an additional 49 acres of wetlands. The degradation of the L-29 levee provides an

additional 32 acres of wetlands in Alt 4 (approximately three miles). The construction of the Blue Shanty Levee to create the flow way between WCA 3B and ENP removes 84 acres of wetlands in WCA 3B in Alts 4 (approximately 6.25 mile levee). If the new levee is not constructed and water stages are not raised substantially within WCA 3B, then significant southward movement of water into NESRS from WCA 3B cannot be achieved by gravity flow alone due to higher wet season stages in the L-29 Canal associated with the implementation of the TTNS Project implementation; it must instead be driven by pumps. These pumps in turn would require additional dredging of former remnant agricultural ditches within southern WCA 3B to create expanded intake canals. The disturbance footprint would potentially be similar to that of the new levee. Focusing instead on Alt 4, we note that creation of the new levee enables the removal of a similar length of existing levee (L-67C).

In Everglades National Park, the backfill of the entire L-67 Extension canal provides an additional 104 acres of wetlands in Alts 2, 3 and 4. In Alt 1, only the southernmost 1.5 miles is backfilled, adding 29 acres of wetlands.

In addition to the benefit of increased wetland/upland acres, the wetland function increases as well due to the backfilling of the Miami Canal and the restoration of sheetflow across WCA 3A and 3B into ENP. The initial construction may have a temporary adverse affect on the wetland function in the construction areas, but once the project is complete, all alternatives would increase wetland function based on the acres of wetlands gained.

Table C.2.1-7. Impacts to Wetlands/Uplands (acres) for each project feature for each alternative.

Project Feature	FWO Acres of Wetland Gain (Loss)	Alternative 1 Acres of Wetland Gain (Loss)	Alternative 2 Acres of Wetland Gain (Loss)	Alternative 3 Acres of Wetland Gain (Loss)	Alternative 4 Acres of Wetland Gain (Loss)
L-4 Degrade	0	35	35	35	35
Miami Canal Backfill	0	417	469	469	469
Miami Canal Spoil Mounds	0	45	49	49	49
L-67A Culverts	0	(4.5)	(13.5)	(18)	(13.5)
L-67C Gaps	0	9	27	36	9
L-67C Flow Way Degrade	0	0	0	0	49
L-29 Degrade	0	0	0	0	32
Blue Shanty Levee	0	0	0	0	(84)
L-67 Extension Backfill	0	29	104	104	104
Total Net Change	**0**	**531**	**671**	**675**	**650**

C.2.1.16.2 Agriculture

The entire CEPP project area consists of lands currently under public ownership. 14,000 acres in the A-2 FEB footprint are currently in production for sugar cane. All action alternatives would convert 14,000 acres of agricultural lands to wetlands due to construction of the A-2 FEB. As described in **Section 5.1.8**, Hydrology, negligible changes were noted for water stages within the SDCS; therefore no indirect effects to agriculture within this region are anticipated. Coordination with the United States Department of

Agriculture (USDA) and National Resources Conservation Service (NRCS) to meet the requirements of the Farmland Protection Policy Act, is ongoing. When detailed design information that locates each of the plan components is completed, it can then be determined how many acres of unique farmland would be affected by the Project. (Refer to **Appendix C.4.12**).

C.2.1.17 Cultural Resources

The Everglades and associated ecosystems are a nationally significant resource and have been severely impacted by human activities for over a hundred years, primarily through drainage practices and agriculture. A review of the Florida State Master Site Files (FSMSF) indicate that there are 23,499 recorded cultural resource sites and resource groups within the CEPP study area that have a survey determination and/or State of Florida Historic Preservation Office (SHPO) evaluation of other than ineligible for listing with the National Register of Historic Places (NRHP). For this document, the use of the term cultural resources includes significant historic properties that are determined eligible or potentially eligible for NRHP listing and culturally significant sites. See **Section 10** in the Main Document for definitions of terms.

Avoidance of adverse effects to cultural resources is the Corps preference, therefore, throughout the planning process for CEPP, the project archaeologist, engineers, and plan formulators have worked closely to determine alternatives and features of alternatives that reduce or eliminate impacts to cultural resources. Pursuant to 36 CFR 800.1, where possible, the project design will be modified to avoid impacting significant historic properties and culturally significant sites. Where avoidance is not possible, other mitigation measures will be considered, which could include but are not limited to data recovery excavations. The mitigation measures will be developed in consultation with SHPO, tribal groups and other interested parties as established in implementing regulations for Section 106 of the NHPA.

In conjunction with the National Historic Preservation Act (NHPA), formal consultation was initiated with the Seminole Tribe of Florida's Tribal Historic Preservation Office (THPO); the Miccosukee Tribe of Indians of Florida's NAGPRA Representative; the SHPO; Everglades National Park's Chief of Cultural Resources (ENP); and the Florida Bureau of Archaeological Research. During formal consultation, a number of conclusions were drawn: 1. It was determined that additional surveys were needed to identify cultural resources within specific areas of potential effect. 2. It was decided that as the CEPP project progressed, additional surveys may be needed, specifically during the Pre-construction, Engineering and Design (PED) phase, when feature designs were finalized and construction staging areas were determined. 3. Section 106 compliance with the NHPA would be conducted separately from NEPA and would not be completed during the current feasibility phase of the project, however would be complete prior to construction of each feature. See Appendix C.5 for correspondence and/or consultation regarding cultural resources within the project area.

Engineering Regulation (ER) 1105-2-100 Appendix C, paragraph C-4(d)(6)(a) states that results of cultural resources investigations conducted during the feasibility phase and if needed, the PED phase will "serve as the basis for formulation of plans for management of historic properties prior to or during the construction and operational stages of projects". At which time, as required under ER 1105-2-100 Appendix C, paragraph C-4 (d)(6)(b) the USACE will determine effects to historic properties and any need "to mitigate adverse project effects on National Register and eligible properties" and to "serve as the basis for negotiation of a Memorandum of Agreement (MA) (if no MA has been previously prepared) with the SHPO/THPO and, if appropriate, the advisory council on Historic Preservation (ACHP) specifying

actions which will be taken by the Corps of Engineers prior to or during the project construction period to mitigate adverse effects on National Register and eligible properties."

This PIR/EIS meets cultural resources requirements as specified under NEPA. The CEPP will remain in compliance with the National Historic Preservation Act (NHPA) pre and post construction.

Area of Potential Effect

The area of potential effect (APE) for cultural resources differs greatly from the overall CEPP study area. For this project, the APE for cultural resources covers 1.5 million acres, which includes the EAA A-2 footprint, portions of the L-6 levee and associated canal, the L-5 levee and associated canal, the S-8 Pump Station Complex, portions of the L-4 levee and associated canal, the L-28 Triangle within the Miccosukee Tribe of Indians of Florida Alligator Alley Reservation, portions of the Seminole Tribe of Florida's Big Cypress Reservation immediately west of L-28 and north of I-75, portions of the Miami Canal, WCA 3A and 3B, L-67A and L67C levee, portions of the L-29 levee, the L-67 Extension levee and associated canal, portions of the Old Tamiami Trail, and portions of the L-31N levee, and Everglades National Park (see **Table C.2.1-7** in **Appendix C.1.16**).

Evaluation Criteria Specific to Cultural Resources Impacts to cultural resources vary by individual components within Alts 1 – 4. Therefore, impact evaluations were based on a review of the individual components of each Alt to determine if actions would potentially result in impacts to significant cultural resources (which include sites eligible or potentially eligible for NRHP listing), described below. Throughout the development and selection of the components, mitigation measures that would eliminate or lessen adverse cultural resource effects were utilized.

The following significance thresholds have been used in determining whether components proposed for each Alt would result in a significant impact to cultural resources. The use of the term cultural resources includes historic properties eligible or potentially eligible for NRHP listing and culturally significant sites. A cultural resource impact is considered significant if implementation of a component of an Alt would result in any of the following when compared to Future Without Conditions (FWO):

- Result in a change in the significance or eligibility for NRHP, including but not limited to any contributing elements, of a historical resource
- Result in an adverse change in the significance or eligibility for NRHP of a historic resource
- Disturb any human remains, including but not limited to those outside of formal cemeteries*
- Disturb memorials determined to hold public significance regardless of age
- Result in adverse changes to sites identified through consultation with the Seminole Tribe of Florida and/or the Miccosukee Tribe of Indians of Florida as having cultural significance.

* The Corps is currently drafting a new policy guidance memorandum to update and expand the 2008 CERP Policy on Human Remains that currently applies to the CEPP study area, to apply to all Civil Works and Regulatory actions within the respective jurisdiction of these Jacksonville District programs in the state of Florida. This document is an internal guidance memorandum designed to consolidate and clarify existing Corps documents regarding the treatment of human remains pursuant to Section 106 of the NHPA and the Jacksonville District's Federal Trust Responsibilities for the state of Florida.

Comparison of Proposed Action Alternatives 1 through 4 and Future Without Conditions

The project schedule (**Section 6.7 and 6.11.2.3**) allows for a phased approach to Section 106 compliance, in that each suite of features will be consulted on as they arise. This will ensure that the most up to date information will be considered in the determination of effect. Also, based on final designs or modifications of the project features, additional work may be required for compliance with

the NHPA. *While the Corps is currently in compliance with the procedural requirements of the NHPA, the Corps recognizes that additional consultation and other requirements are not yet complete, but the project will be in full compliance prior to construction.*

Consultation is currently ongoing with regards to the determination of effects and potential mitigation of effects listed below, and therefore should be considered preliminary. The effects associated with each Alt have been preliminarily considered for this feasibility study. A final determination of effects, as required under Section 106 of the NHPA, will not be made until the project is authorized and the subsequent PED phase begins.

For each component discussion below, the environmental effect is determined when compared to the future without conditions. For this document, the use of the term cultural resources includes significant historic properties that are determined eligible or potentially eligible for NRHP listing and culturally significant sites. See **Section 10** in the Main Document for definitions of terms.

C.2.1.17.1 Draft Preliminary Operations Manual (DPOM)

This component of CEPP involves the development of a draft preliminary operation plan for each component or feature of the project. More information about the draft preliminary operation plan is recorded in **Section 6.6.5**. It should be noted that currently there are approximately 350 significant or NRHP eligible cultural resource sites, including five districts and one World Heritage site (ENP) recorded within the APE for CEPP. There are also numerous culturally significant properties to both the Seminole Tribe of Florida and the Miccosukee Tribe of Florida within WCA 3 and Everglades National Park.

Two significant traditional cultural properties (TCP), Airboat Association of Florida (8DA6768A) and Coopertown (8DA6767A), associated with the modern Gladesmen culture group, and one Miccosukee Tribe of Indians of Florida residential camp (Osceola Camp) are located south of the L-29 levee. These properties are considered culturally significant. Also, three structures (8DA6768, 8DA11526, and 8DA115267) are located on and associated with 8DA6768A and are considered significant historic properties.

Effects: For this component of CEPP, there are many uncertainties, some of which are identical to those described in the ERTP EIS. Ongoing ERTP investigations center around uncertainties surrounding the effects fluctuating water would have on subsurface cultural material. Another uncertainty is the velocity that water will be flowing from the L-4 Spreader feature and from within the Blue Shanty flowway. Water velocity can cause erosional effects, which would be considered an major adverse long term effect to historic properties. Once a determination of effects of fluctuating water on cultural resources has been identified for ERTP (ca. 2016) and the CEPP enters into the PED phase and modeling information is refined, Section 106 consultation for the CEPP DPOM will continue.

Alternatives 2 – 4 could potentially affect the TCP 8DA6768A and associated historic properties 8DA6768, 8DA11526, and 8DA115267). Based on the Department of Interiors ongoing mitigation of Coopertown (8BD6767A) as part of Tamiami Trails Next Steps, there will be no effect.

During the PED phase and refinement of the DPOM, consultation with all interested parties will resume and an effects determination will be made prior to operation.

Mitigation of Effects: Mitigation for the TCP Airboat Association of Florida (8DA6768A) could potentially involve purchasing any necessary easements, which would reduce any adverse effect. Effect to

8BD6768A associated historic structures, could be reduced by potentially raising the structures. For the remainder of the effects caused by the DPOM, mitigation is unknown at this time.

North of the Redline

C.2.1.17.2 Lake Okeechobee

There are no changes from the future without conditions for this component of CEPP. Effects: There will be no effect to cultural resources for Alts 1 through 4.

C.2.1.17.3 Northern Estuaries

This component of CEPP proposes to redirect a percentage of water currently flowing from Lake Okeechobee into the eastern and western northern estuaries, south into the Miami Canal and the North New River Canal. Effects: This decrease of freshwater into the estuaries will have no effect to cultural resources for Alts 1 through 4.

C.2.1.17.4 EAA A-2 FEB

The EAA A-2 FEB consists of a perimeter levee to confine the water, potential grading within the interior of the FEB footprint, improvements to existing agriculture canals, and improvements to existing and/or constructing new structures or features. A cultural resource Phase I Survey of this project component was conducted specifically for CEPP in 2013 to identify and assess cultural resources within the FEB footprint. As a result, four historic sites were identified, two of which are considered significant (8PB16039, 8PB16040) under NEPA. Effects: Effects to cultural resources sites 8PB16039 and 8PB16040 for Alts 1 through 4 are considered major and long-term and adverse. Mitigation of Effects: Due to the lack of knowledge of prehistoric occupation sites within the area, Phase III Investigations are recommended for historic property 8PB16039, which would reduce the effect. Site 8PB16040 contains human remains and is therefore a culturally significant resource. Mitigation of effects are unknown at this time and will be determined through consultation once the project is implemented.

A new structure (S-623) associated with the operation of A- 2 FEB would be constructed along the NRHP eligible Miami Canal (8PB13369). Effects: There would be no effect to cultural resources for Alts 1 through 4. The proposed new structure would not alter either directly or indirectly the characteristics which make the Miami Canal (8PB13369) significant.

Existing structures G-373, G-372 and G-372HL are associated with the operations of STA 3/4 and date to the 1990's, and are therefore not significant. Effects: There would be no effect to cultural resources for Alts 1 through 4.

C.2.1.17.5 L-28 Triangle (levee and borrow canal)

The L-28 Triangle area is located entirely within the boundaries of the Miccosukee Tribe of Indians of Florida's Reservation and encompasses 7830 acres of Tribal lands. The L-28 Triangle area is confined north by Interstate 75, west by L-28 Interceptor Canal (L-28I), and east by the L-28 Canal or WCA 3A. Alternative 1 includes removal of two segments of the L-28 Levee along the eastern boundary of the L-28 Triangle (9000 feet total) and complete backfill of the L-28 Canal segment located between the levee gaps. Although Alts 2 through 4 do not include modifications to the L-28 Levee or the adjacent canal, stages within the L-28 Triangle are slightly increased by 0.1-0.2 feet during normal to dry conditions, due to groundwater interactions with the down-gradient western WCA 3A marsh. Effects: Effects to historic properties for Alt 1 is unknown. Through consultation with the NAGPRA representative to the Miccosukee Tribe of Indians of Florida, there are no known culturally significant sites within the area, and areas within the footprint of the L-28 levee and associated borrow canal are considered to have low

probability for historic properties. Based on previous research within the immediate area and/or similar areas ecologically, tree islands (either historic or modern) are considered to have a high potential for cultural resources. Therefore, cultural resource investigations will be conducted within high probability areas impacted by the original construction of the L-28 levee and canal. If significant historic properties are located within the area of potential effect, long-term, major adverse effect could occur as a result of degrading the levee. The L-28 Triangle is not a feature in Alts 2 through 4, therefore there would be no effect to cultural resources. Mitigation of Effects: If significant historic properties are located, adverse effect to sites could be reduced by avoidance. To avoid potential inadvertent discoveries, it is recommended that should the levee be removed within the historic footprint of tree islands, that degrading be terminated at tree island grade, not marsh grade. Previous research has shown that compacted spoil material can extend well below tree island grade. Additionally, a professional archaeologist should monitor construction activity to ensure that any discovery is recorded and assessed for significance.

South of the Redline

C.2.1.17.6 L-4 Levee and Canal

This component involves degrading the western 2.9 miles of the southern L-4 levee, resulting in the creation of a water spreader feature at the northwestern most boundary of WCA 3A. A pump station near the western terminus of the L-4 degrade would also be constructed. Exact placement of the pump station has not been determined. Although built in ca. 1957, the L-4 Levee and Borrow Canal (8BD5098) is considered a tertiary canal and not a part of the original reclamation/drainage activities of the early 20th century, which is considered by SHPO and USACE to be the period of significance for eligibility determination. Therefore, 8BD5098 is not considered eligible for the NRHP, nor significant under NEPA. Effects: There would be no effect to cultural resources for Alts 1 through 4 in the degrading of the southern L-4 levee, nor for the placement of the proposed L-4 Pump Station, regardless of location along the levee/canal.

C.2.1.17.7 S-8 Complex

This component of CEPP involves modifications to the S-8 Pump Station (8BD5092) and potentially other structures (G-357, G-404, and L-5-1 bridge) in the vicinity of the pump station to permit flows to the west. Further work is needed to determine if the S-8 Pump Station (8BD5092) is eligible for NRHP listing and therefore is significant under NEPA. The G-357 Gated Culvert, G-404 Pump Station, and L-5-1 bridge have been either constructed or replaced in the last 20 years and are not considered significant. Effects: A determination of eligibility is need for the S-8 Pump Station (8BD5092) prior to making a determination of effect. Mitigation of Effects: If the S-8 Pump Station is determined significant and adverse effect to any component of the S-8 Pump Station complex are unavoidable, a qualified architectural historian should conduct a Historic American Engineering Record (HAER) and/or Historic American Buildings Survey (HABS). This documentation packet will then be entered into the Library of Congress as well as Florida Master Site Files. These measures would reduce effects to this potentially historic property, if needed.

C.2.1.17.8 L-5 Levee , Canal and Spreader Feature

Alternative 1 of this component involves improvements to accommodate L-6 and STA 3/4 conveyances, by deepening the L-5 borrow canal and the placement of a gravity pump. The L-5 southern levee and associated borrow canal (8BD5099) are not significant. The L-5-1 bridge that joins the L-5 north levee to the L-5 south levee was replaced in the last 20 years and is not eligible for NRHP, nor is the bridge considered significant under NEPA. Effects: There will be no effects to historic properties for this component of Alts 1 through 4.

Alternatives 2 through 4 are similar in that they call for the same conveyance and improvement features as Alt 1, with the addition of a separate spreader feature constructed approximately 600 ft. south and parallel to portions of the existing L-5 south levee. Phase II Excavations were carried out specifically for the CEP Project on three previously recorded historic properties (8BD4836, 8BD4837, and 8BD4838) located within the APE of this project component. All three sites where recommended eligible for the NRHP and contained material culturally sensitive to the tribes. Effects: This component of Alts 2 through 4 will result in major long-term adverse effects to cultural resources 8BD4836 – 8BD4838. Mitigation of Effects: Effects to cultural resources for Alts 2 through 4 are potentially reduced by considering the placement of the spreader features (avoiding) and/or consideration of water velocity in relation to the significant site locations.

C.2.1.17.9 L-6 Levee and Canal

This component involves deepening and/or widening the L-6 borrow canal, replacement or redesign of the G-336G culverts and removal of the L-6 canal plug. The G-336G and the L-6 canal plug were originally constructed in association with WCA2 operations and are not historic. The L-6 borrow canal appears on historic aerial photographs (Armando Ramirez, personal communication 2013) and therefore would require additional work to determine significance or NRHP eligibility. Effects: Effects to historic properties for this component of the Alts are unknown. Cultural resource investigations would be needed to assess significance of the L-6 levee and associated borrow canal. Mitigation of Effect: If it is determined that the L-6 is a significant historic property, it is recommended that a Level I Historic American Engineering Record (HAER) document is written and submitted to the Library of Congress and the Florida State Archives. This action would reduce the effect.

C.2.1.17.10 Miami Canal (8BR4840/8BR5097)

To improve sheet flow throughout WCA 3A, a portion of the Miami Canal (8BR4840) would be backfilled using spoil material originally excavated during the construction and maintenance of the canal and dredged material from the L-5 modifications. The Miami Canal and associated features/structures have been investigated during seven separate surveys (FMSF Survey # 5844, 14404, 17583, 19090, 19276, 20328, and 20487). As a result, it has been determined that the Broward County reach of the Miami Canal (8BD4840) is eligible for the National Register of Historic Places (NRHP) and is therefore considered significant under NEPA. Effects: Effects to historic properties for Alt 1 are considered major long-term adverse effects to the Miami Canal (8BD4840). Effects to historic properties for Alts 2, 3, and 4 would be similar to the effects of Alt 1, with differences being a larger portion of the Canal would be adversely effected, including one additional potentially significant feature. Through consultation with the Tribes (**Appendix C.5**), it has been determined that the spoil mounds associated with the Miami Canal do not contain culturally significant sites (i.e., culturally significant flora and/or other culturally sensitive uses), therefore a determination of no effect to culturally significant sites is listed for the use of the spoil material. Mitigation of Effects: It is recommended that a Level I or II Historic American Engineering Record (HAER) document is written and submitted to the Library of Congress and the Florida State Archives. This would reduce the effects of the proposed action.

Greenline/Blueline

C.2.1.17.11 L-67A Levee and Canal

This component involves the placement of gated structure(s) within the L-67A levee and the removal of spoil material deposited during the original construction or maintenance of the L-67A borrow canal and will span approximately 0.5-miles on each side of the structure(s).

Three cultural resource surveys are listed with the State for WCA 3A, one conducted via aerial photographs (FMSF Survey # 602), a Phase I Survey conducted in 2011 (FMSF Survey # 20487) and a Phase I and Phase II Survey conducted in 2012 specifically for CEPP (FMSF Survey # 20328). During the 2011 survey, the L-67A levee and associated canal (8BD5100) was assessed and determined to be not significant. Results of the 2012 cultural resources survey conducted specifically for CEPP included testing portions of tree islands impacted by the original levee/borrow canal construction. In some cases this involved portions of tree islands with recorded sites that were identified during Survey # 602 using aerial photography. These sites have not been field verified. Only areas of potential effect for sites recorded during Survey # 602 were investigated for CEPP. It also should be noted that existing As-Built Plans for the L-67A and C show that the area immediately underneath the existing levee, and areas between the levee and borrow canal were degraded prior to construction. During the CEPP specific 2012 Survey (FMSF Survey # 20328), no significant cultural resources were identified.

Two culturally significant sites actively used by the Miccosukee Tribe of Indians of Florida are located on two of the spoil mounds west of the borrow canal. Effects: Potential effects to the culturally significant sites for Alts 1 through 4 are considered major to moderate long-term adverse effects. There will be no known effects to historic properties. Mitigation of Effects: Effects to the culturally significant sites could be reduced by avoiding the spoil mounds associated with the sites during the PED and construction phase of CEPP. Also, to avoid potential inadvertent discoveries, it is recommended that should spoil mounds be removed within the historic footprint of tree islands, that degrading be terminated at tree island grade, not marsh grade. Previous research conducted by Corps' archaeologist has shown that compacted spoil material can extend well below tree island grade. Additionally, a professional archaeologist should monitor construction activity within historic tree island footprints to ensure that any discovery is recorded and assessed for significance.

C.2.1.17.12 L-67C Levee and Canal

This project component involves degrading portions of the L-67C Levee, lengths of which are dependent upon the Alt.

Two surveys have been conducted to identify significant historic properties within WCA 3A, one conducted via aerial photographs (FMSF Survey # 602) and a Phase I and Phase II Survey conducted in 2012 specifically for CEPP (FMSF Survey 20328). For tree islands impacted by the original levee/borrow canal construction, only areas of potential effect were investigated. In some cases this involved portions of tree islands with recorded sites that were identified during Survey # 602 using aerial photography. These sites have not been field verified. Sites previously identified during Survey #602 were only investigated in the area of potential effect for this component of CEPP only. It should also be noted that existing As-Built Plans for the L-67 A and C, show that the area immediately underneath the existing levee, and area between the levee and borrow canal were degraded prior to construction. During the 2012 Survey (FMSF Survey 20328), no cultural resources were identified within the APE for this feature. Also the L-67C was built in 1968 and therefore does not meet the age criteria of 50-years required for accessing eligibility. Based on information gathered during the assessment of L-67A, once the age criteria is met, it is probable that the L-67C is not historically significant.

Effects: There would be no effect to significant cultural resources for Alts 1 through 4. However, to avoid potential inadvertent discoveries, it is recommended that should levee material be removed within the historic footprint of tree islands, that degrading be terminated at tree island grade, not marsh grade. Previous research has shown that compacted spoil material can extend well below tree island

grade. Additionally, a professional archaeologist should monitor construction activity within historic tree island footprints to ensure that any discovery is recorded.

C.2.1.17.13 L-29 Levee

This component involves degrading of portions of the L-29 Levee (Alt 4 only) and/or new structures (Alts 2-4) located east of S-333. This component is not applicable to Alt 1. The original construction of the L-29 impacted two large tree islands. Through consultation with the Cultural Resource Representative to the Miccosukee Tribe of Indians of Florida, these islands have been identified as being culturally significant. Multiple surveys have been conducted to identify cultural resources within WCA 3A and 3B, one conducted via aerial photographs (FMSF Survey # 602), Survey # 17032, Survey # 283, a Phase I Survey conducted in 2011 (FMSF Survey 20487), and a Phase I and Phase II Survey conducted in 2012 specifically for CEPP (FMSF Survey # 20328). With information gathered from these surveys and others in similar environments, it is highly probably that historic properties will also be located on these islands.

The ValuJet Flight 592 Crash Memorial is also located along the L-29 levee. Although the Memorial is not historic, it is frequently visited by those directly or indirectly affected by the accident. Therefore, the Memorial is considered culturally significant and should be preserved in place. If preservation is not viable, consultation with all family members of the victims, and local residents should occur prior to completion of the design-build phase.

There is also one Miccosukee Tribe of Indians of Florida residential camp (Tigertail Camp) located atop the L-29 levee. The Tigertail Camp is considered culturally significant.

Effects: Alternative 1 does not involve removal of the L-29 levee or placement of new structures, therefore would have no effect to significant cultural resources. Alternative 2 -4 could potentially have major long-term adverse effects to two culturally significant sites identified by the Miccosukee Tribe of Indians of Florida. Impact to portions of these two sites occurred during levee and borrow canal construction in the mid-late 1960's. Based on previous research, it is highly probable that these two tree islands could contain historic resources of unknown significance. It should be noted that cultural resources investigations on these islands would require further consultation with the Miccosukee Tribe of Indians of Florida prior to fieldwork. Based on preliminary design plans for Alternatives 2 through 4, there would be no effect to the Valujet Flight 592 Crash Memorial, or the Tiger Tail Camp. Mitigation of Effects: Avoid placing structures or degrading L-29 within known culturally significant sites, significant historic properties, currently occupied camps, and/or within the footprint of the Valujet Flight 592 Crash Memorial could reduce the determination of effect. Potential adverse effects to historic properties impacted by the original levee construction could be reduced to no effect by avoiding tree islands and/or by limiting the depth of levee removal to not exceed tree island grade. Additionally, a professional archaeologist should monitor construction activity within historic tree island footprints to ensure that any discovery is recorded

C.2.1.17.14 S-333 Modifications

This component of CEPP involves constructing an additional structure (S-333N) to increase the S-333 capacity and is a feature of Alts 1 - 4. The S-333N would be located just north of the S-333. Exact placement of the structure is preliminary.

There are no known high probability areas for cultural resource sites located within the APE. The ValuJet Flight 592 Crash Memorial is also located along the L-29 levee just east of the S-333 structure. Although the Memorial is not historic, it is frequently visited by those directly or indirectly affected by

the accident. Therefore, the Memorial is considered culturally significant and should be preserved in place. If preservation is not viable, consultation with all family members of the victims, and local residents should occur prior to completion of the design and build phase. Effects: Based on preliminary design plans for Alternatives 1 through 4, there would be no effect to the Valujet Flight 592 Crash Memorial.

C.2.1.17.15 L-67D Levee and Flow way within WCA 3B (Blue Shanty)

This component is a feature of Alt 4 only and involves constructing a levee within WCA 3B to connect the L-67A levee with the L-29 levee, thereby creating a flow way for water to pass from WCA 3A into Shark River Slough. Working closely with project engineers, areas of concern have been identified in an effort to avoid significant cultural resources or areas of high probability (i.e. tree islands and areas currently in use by the Miccosukee Tribe of Indians of Florida) within the footprint of the proposed levee. Based on the multiple surveys conducted within similar environmental areas (FMSF # 602, 286, 1616, 17032, 18093, 1615, 904, 1009, 1014, 1187, 1307, 6968, 7667, 20487 and the CEPP specific 2012 Survey (FMSF # 20328) and in conjunction with consultation with the Tribes, there is a high probability for significant cultural resources to be located within the flow way. Also, modeling results indicate that water depth could exceed current stages to the point that it could prove detrimental to lower elevated tree islands within the flow way that have not undergone a Phase I Survey. The exact footprint of this feature is unknown at this time. Effects: Alternatives 1 through 3 would have no effect. Alternative 4 effects are unknown. Once the footprint of the L-67D levee and the APE for the flow way is determined, and early in the PED phase, an integrated Phase I and Phase II Survey would be conducted to identify and assess significant cultural resources that may be located on high probability areas (tree islands) within the proposed flow way. Mitigation of Effects: Unknown at this time. It is recommended that the levee avoid impacting tree islands.

C.2.1.17.16 L-67 Ext. Levee Removal

This component involves the backfilling of the L-67 Extension borrow canal using associated levee material to varying degrees depending on the Alt. This component is located within ENP. In January 2013, USACE and ENP employees conducted a survey (FMSF # pending) of potential high probability areas impacted by the original construction of the L-67 Extension levee and associated borrow canal. The L-67 Extension levee and associated borrow canal (ca. 1967), and associated features S-347 (1987), and S-346 (1987) do not meet the age criteria of 50-years required for accessing NRHP eligibility, nor are these features eligible under Criteria G See SHPO to Corps letter dated 10-15-2013 in Appendix C.5. Based on information gathered during the research of other canals, levees, and features within the CEPP APE, it is highly probable that the L-67 Ext. and associated features are not eligible for NRHP listing and therefore will not be considered historically significant.. No significant cultural resource sites were located. Effects: There would be no effect to cultural resources for Alts 1 through 4. However, to avoid potential inadvertent discoveries, it is recommended that should levee material be removed within the historic footprint of tree islands, that degrading be terminated at tree island grade, not marsh grade. Previous research has shown that compacted spoil material can extend well below tree island grade. Additionally, a professional archaeologist should monitor construction activity within historic tree island footprints to ensure that any discovery is recorded.

Yellowline

C.2.1.17.17 L-31N Seepage Barrier / L-31N Pump Station(s)

This component involves the construction of a seepage barrier within the existing L-31N levee for all Alts and/or the construction of pumps for Alts 1 and 2. Three surveys have been conducted along the L-31N Levee (FMSF Survey # 11698, 16709, and 18093), which resulted in the identification of one site

recommended as potentially eligible for the National Register. The USACE concurs with this recommendation and considers 8BD2104 as eligible for NRHP listing. Effects: For Alts 1 through 4 seepage barrier, there would be no effect to cultural resources. There could potentially be major long-term adverse effects to the Levee Cut Site (8BD2104) dependent upon placement of the proposed structures for Alts 1 and 2. Mitigation of Effects: Consideration should be given to the placements of the proposed structures during the PED phase. If placement avoids direct or indirect impact to site 8DA2104, then a no effect determination would be made. The effect determination for 8DA2104 should be revisited once feature specific plans and specification for the project are developed.

C.2.1.17.18 S-356

This component involves changes to the S-356 Pump Station. Based on examination of historic aerial photographs, the original construction of the pump station did not impact any tree islands within the construction footprint. As previously stated, based on previous research, tree islands are considered high probability for cultural resource locations. Effects: The S-356 Pump Station is not a historic structure, nor did original construction impact areas of high probability areas. Regardless of the changes proposed to the S-356, there would be no effect to cultural resources for Alts 1 through 4.

C.2.1.17.19 G-211 Operational Refinements

This component involves the utilization of current coastal infrastructure (canals and associated features) to convey seepage south. Effects: For Alts 1 through 4, there would be no effect to cultural resources.

C.2.1.17.20 S-334 to S-335 Seepage Barrier

This component involves the construction of a seepage barrier within the existing levee between structures S-335 and S-334. This component is located adjacent to the Miccosukee Tribe of Indians of Florida lands and casino. Effects: This is not a feature of Alts 1, 3, and 4. For Alt 2, there would be no effect to cultural resources.

C.2.1.18 Invasive and Native Nuisance Species

Alternatives 1, 2, 3, and 4 have the potential and likelihood for establishment and spread of non-native invasive and native nuisance species. Proposed restoration activities may affect ecosystem drivers that directly or indirectly influence the invasiveness of non-native species. These factors may affect invasive species positively or negatively, depending on the unique characteristics of individual species and the environmental conditions for a given biological invasion (Doren et al. 2009). For example, shortened surface water drawdowns may reduce the recolonization rates of melaleuca in sawgrass marsh while increasing habitat suitability for Old World climbing fern on tree islands. Many of the areas where features are proposed are currently inhabited by non-native invasive and native nuisance species. Construction of the proposed features has the potential to spread the existing non-native invasive and native nuisance species on site as well as introduce new invasive species via contaminated equipment. Disturbed areas resulting from construction are likely to become established with non-native invasive and native nuisance species. New flows created by operations of the proposed features may serve as vectors to spread invasive and native nuisance species into new areas. The large number of existing and potential invasive plant and animal species and the often incomplete knowledge of invasive mechanisms for each species create moderate to high uncertainty in this evaluation. Long-term monitoring in an adaptive management framework is critical to ensure efficient management of the most threatening non-native invasive species in the restoration footprint.

C.2.1.18.1 Lake Okeechobee and the Northern Estuaries

Alternatives 1, 2, 3, and 4 would reduce freshwater flows from Lake Okeechobee to the Caloosahatchee and St. Lucie estuaries, allowing for slightly higher salinity levels in the estuaries. The reduced freshwater outflows are not expected to have an impact on non-native invasive or native nuisance species. Existing invasive species under active management are expected to persist at baseline levels if current funding levels are sustained (e.g., melaleuca). Existing species not under active management or which are ineffectively controlled are expected to increase in abundance and spatial extent (tropical American water grass). New invasions of non-native plant and animal species are expected but estimates of species number and severity of impacts are conjectural.

C.2.1.18.2 A-2 Flow Equalization Basin

Alternatives 1, 2, 3, and 4 include this feature. There are invasive and native nuisance species to consider with the proposed Flow Equalization Basin (FEB), to be called A-2. Species of concern include Brazilian pepper, torpedo grass, tropical American watergrass, water hyacinth, water lettuce, and hydrilla. The FEB lands currently are agricultural lands. Brazilian pepper exists along the agricultural canals. Once the FEB is operational, the water levels are likely to inhibit growth and recruitment of Brazilian pepper. All upland sites (e.g., levees) are expected to experience colonization of Brazilian pepper, torpedo grass, paragrass, and other invasive species common in ruderal sites. The proposed four-mile spreader canal would require continual maintenance of floating, emergent, and potentially, submersed plant species in order to maintain the function of the canal. It is expected that increased sedimentation immediately downstream of the spreader would result in succession to large stands of Carolina willow and cattail and this area may require maintenance to achieve target flow rates. In addition, the seepage canal would require continual maintenance to control both non-native invasive and native nuisance species. Due to eutrophic conditions and variable hydroperiods, many invasive species would aggressively invade and are likely to be costly and difficult to control. Therefore, control efforts focused at maintaining the primary functions of the FEB (e.g., conveyance capacity) are preferred over aggressive eradication efforts typically applied to natural areas. Invasive/nuisance species in this category include, but are not limited to torpedo grass, hydrilla, water hyacinth, and water lettuce. In all action alternatives, these species have the potential to interfere with surface water conveyance immediately upstream of water control structures. There are many species that could establish both in the FEBs and WCAs. Establishment of these species in the FEB could be part of an invasion pathway to natural areas downstream (i.e. WCA 3A/3B, ENP). For this reason, diligent monitoring and rapid response control measures for these species would need to be carried out during construction and operations phases. Examples of such species include tropical American watergrass, Wright's nutrush, West Indian marshgrass, Nile monitor, and bullseye snakehead.

There are two recreational access points proposed for the FEB. Access points provide opportunity for the introduction of invasive species, such as hydrilla and torpedo grass. Boats and trailers can serve as a vector for new species introductions.

C.2.1.18.3 Diversion of L-6 Flows and L-5 Improvements

This feature is proposed for Alts 1, 2, 3, and 4. Deepening of the L-5 has the potential to reduce productivity of various species of SAV (including hydrilla), but would not eliminate suitable habitat for their establishment and growth (Langeland 1996). All of the action alternatives may improve habitat for non-native tropical fish species which utilize deep water zones to avoid cold temperature events (Trexler et al. 2000).

C.2.1.18.4 L-4 / L-5 – Spreader Canal and Levee Degradation

The effects to invasive species with this feature would be similar for Alts 1, 2, 3, and 4. Northwest WCA 3A has dried out significantly since the area was compartmentalized. The vegetation has shifted from ridge and slough to woody shrubs and small trees including Carolina willow, wax myrtle, Brazilian pepper, and melaleuca. The flows provided by the spreader canal into northwest WCA 3A are expected to increase wet season stages and decrease duration of surface water draw downs in the northern portions of WCA 3A. This may reduce recruitment rates of some invasive or nuisance species, such as Carolina willow and Brazilian pepper, and may facilitate expansion of other invasive or nuisance species, such as cattail and paragrass. The proposed spreader canal would require continual maintenance of floating, emergent, and potentially, submersed plant species in order to maintain the function of the canal. It is expected that increased sedimentation immediately downstream of the spreader would result in succession to stands of Carolina willow and cattail and this area may require maintenance to achieve target flow rates. Similar areas in ENP are also invaded by Brazilian pepper and Old World climbing fern. The remaining portions of the levee would offer suitable habitat for Burmese pythons. Invasive species could be introduced into northern WCA 3A with the new flows from the spreader canal. The degraded levee area may be invaded by non-native invasive and native nuisance obligate wetland plant species.

Model output for WCA 3A suggests substantial decreases in dry out periods in the northern reaches of WCA 3A. This is likely to reduce the rate of spread for certain species, especially Brazilian pepper, Australian pine, torpedo grass, and Napier grass. Melaleuca recruitment would also continue but at a reduced rate. Other species more suited to longer periods of inundation may find conditions more favorable for establishment and spread. These include but are not limited to Old World climbing fern, Island apple snail, West Indian marsh grass, paragrass, and potentially Peruvian primrose willow. Diligent monitoring and control efforts would be recommended to minimize establishment of new plant species in these areas.

Continued maintenance of the remaining portions of the L-4 levee is assumed. If regular mowing is not carried out, this segment of levee would become invaded by a number of invasive plants and animals, such as Brazilian pepper, napier grass, bishopwood, cogongrass, Burmese pythons, feral hogs, and Nile monitors.

C.2.1.18.5 Miami Canal Backfill – S-8 to Interstate 75

The effects to invasive species would be the same for Alts 1, 2, 3, and 4. Backfilled portions of the Miami Canal may be invaded by non-native invasive and native nuisance wetland plant species. Invasion by paragrass, torpedograss, and cattail is expected if backfill operations result in elevated nutrient availability. Spoil mounds along the Miami Canal in WCA 3A currently supports high densities of Brazilian pepper and other invasive plants. Degradation of these spoil deposits would result in the removal of approximately 200 acres of Brazilian pepper. This will reduce an important seed source and lower bird dispersal to nearby tree islands. While there is uncertainty about the impacts of non-native fish species on native fauna (Trexler et al. 2000), backfilling the canal would reduce available deep water habitat for non-native fish species and could reduce further expansion.

Preserved planted tree islands and the proposed spoil island creation efforts would experience immediate and long-term susceptibility for biological invasion. Elevated nutrient regimes on the new islands would promote invasion of numerous invasive species, including Brazilian pepper, Napier grass, climbing cassia, Peruvian primrose willow, and torpedograss. These elevated areas are also expected to provide excellent habitat for Burmese pythons and Nile monitors.

C.2.1.18.6 L-28 Levee Degradation / Backfill

Continued maintenance of the remaining portions of the L-28 levee in Alts 1 is assumed. If regular operations and management (O&M) vegetation management is not carried out, fallow segments of levees are likely to be invaded by a number of invasive plants and animals, such as Brazilian pepper, napier grass, bishopwood, cogongrass, Burmese pythons, feral hogs, and Nile monitors. Backfilled portions and the degraded levee area may be invaded by non-native invasive and native nuisance wetland plant species.

C.2.1.18.7 Increase Capacity of S-333

Alternatives 1, 2, 3, and 4 propose increasing the capacity of the S-333 structure. The additional flows are expected to have a minimal effect on invasive species populations. Existing invasive species under active management are expected to persist at baseline levels if current funding levels are sustained (e.g., water hyacinth). Existing invasive species not under active management, or which are ineffectively controlled, are expected to increase in abundance and spatial extent (e.g. roundleaf toothcup). New invasions of non-native plant and animal species are expected but estimates of species numbers and severity of impacts are conjectural.

C.2.1.18.8 L-67A Gated Structures / Spoil Removal

Alternatives 1, 2, 3, and 4 include building one or more gated structures on the L-67A and spoil removal on the west side of the L-67A canal. The effects to invasive species would be same for Alts 1, 2, 3, and 4. The proposed gated structure(s) on L-67A has the potential to spread cattail, torpedograss, and non-native fish species downstream of the structure and into the gap between L-67A and L-67C. Cattail and torpedo grass are also expected to colonize spoil removal areas. It is expected that non-native fish species would establish at the outflow, where water levels are deeper. Existing non-native fish species could move from the canal into the gap, but they are not expected to maintain substantial populations in the marsh due to seasonal drawdowns. Many non-native fish are documented to move from canals to the marsh during the wet season, but do not venture too far from the canal and return to the canal as water levels recede (Trexler 2000). There is a potential for invasion by new aquatic species capable of tolerating seasonal drawdowns, but the number of species and severity is conjectural.

C.2.1.18.9 L-67C Levee Degradation

Alternatives 1, 2, 3, and 4 propose to degrade sections of the L-67C levee. Effects to invasive species due to this feature would be the same for all of the action alternatives. The proposed gap(s) would also provide a pathway for aquatic species currently present in the L-67C canal to spread into WCA 3B. Existing invasive species under active management in WCA 3B are expected to persist at baseline levels if current funding levels are sustained (e.g., melaleuca). Existing species not under active management or which are ineffectively controlled are expected to increase in abundance and spatial extent (Old World climbing fern). New invasions of non-native plant and animal species are expected but estimates of species numbers and severity of impacts are conjectural. The proposed 6,000-foot gap(s) in the L-67C levee would provide an open pathway for cattail spread into WCA 3B. The extent of spread is uncertain.

C.2.1.18.10 Outflow structures out of WCA 3B

Outflow structures are proposed in Alts 1, 2, 3, and 4. Agricultural canals in WCA 3B currently release water into the L-29. There is potential for new non-native invasive species to be transferred from WCA 3A or L-67A through the new culverts and levee degrade area into WCA 3B, L-29 and eventually into ENP.

C.2.1.18.11 Build North-South Levee in WCA 3B

This feature is only proposed for Alt 4. The construction of a north-south levee in WCA 3B would cause significant disturbance within the construction footprint and adjacent marsh. Regular maintenance would be required to ensure non-native invasive plant species do not establish along the levee. Cattail is likely to establish along the entire eastern side of the levee. Existing invasive species in the affected area that are under active management should persist at baseline levels if current funding levels are sustained (e.g., melaleuca). Existing species not under active management or which are ineffectively controlled are expected to increase in abundance and spatial extent. New invasions of non-native plant and animal species are expected but number of species and severity of impacts are undetermined.

C.2.1.18.12 L-67 Extension – Levee Degradation / Backfill

Alternatives 1, 2, 3, and 4 include some degree of degrading the L-67 Extension levee. This canal and levee system extends south into ENP. This area is now invaded by numerous non-native invasive plants and also serves as habitat for Burmese pythons and feral hogs. Removal of the L-67 Extension levee would remove suitable habitat for Brazilian pepper, napier grass, climbing cassia, torpedo grass, guava, and Australian pine. Removal of the L-67 Extension levee would also reduce habitat for the Burmese python, feral hogs, and potentially, the Argentine black and white tegu. Island apple snails may find the degradation footprint as suitable habitat if final grade is lower than the surrounding marsh.

C.2.1.18.13 L-29 Levee Degradation

Alternative 4 proposes some degree of degradation of the L-29 levee. This feature would open surface water connectivity between the L-29 canal and WCA 3B (Blue Shanty flowway). This is likely to promote the expansion of several invasive species currently limited to the L-29 canal, particularly roundleaf toothcup, island apple snail, and numerous non-native fish species. There is uncertainty whether these species would be able to persist far from the canal since many are unable to tolerate conditions during dry season drawdowns.

C.2.1.18.14 Divide Structure on L-29

This feature applies only to Alt 4. This feature is expected to have minimal effect on invasive species. Maintenance of submersed and floating vegetation would be required to ensure operational functionality of the structure.

C.2.1.18.15 Increase S-356 Capacity to 1,000 cfs

Alternatives 1, 2, 3, and 4 propose to increase the capacity of the existing S-356 structure. The additional flows may slightly reduce recruitment rates of melaleuca and other invasive plants in northern portions of ENP.

C.2.1.18.16 L-31N – New Pump Stations

Alternatives 1 and 2 propose two 250-cfs pumps on the L-31N. The two proposed 250 cfs pumps have high a probability of promoting cattail expansion and introducing non-native aquatic species downstream of the structure and into northeast Shark River Slough. It is likely that non-native fish species would establish at the outflow, where water levels are deeper. The addition of these structures along with new water flow would cause changes in vegetation composition immediately downstream. It is likely growth of Carolina willow and cattail would occur downstream of the structures. Brazilian pepper and Old World climbing fern may also establish if vegetation succeeds to willow swamp.

C.2.1.18.17 G-211 Operational Modifications / Coastal Canals Conveyance

This feature is proposed for Alts 1, 2, 3, and 4, and is expected to have minimal effects on non-native invasive and native nuisance species. Existing invasive species under active management are expected to persist at baseline levels if current funding levels are sustained (e.g., hygrophila). Existing species not under active management, or which are ineffectively controlled, are expected to increase in abundance and spatial extent (e.g., roundleaf toothcup). New invasions of non-native plant and animal species are expected but number of species and severity of impacts are undetermined.

C.2.1.18.18 Penetrating Seepage Barrier

This feature is proposed for Alts 2, 3, and 4. The depth and duration of surface water drawdowns in north eastern ENP are expected to decrease with Alts 2, 3, and 4. These changes in hydroperiods are expected to reduce recruitment rates of Australian pine, Brazilian pepper, and to a lesser extent, melaleuca. These changes may improve conditions for other invasive plant species such as tropical American water grass, West Indian marsh grass, and roundleaf toothcup.

C.2.1.19 References

Acosta, C. A. and S. A. Perry. 2001. Impact of hydropattern disturbance on crayfish population dynamics in the seasonal wetlands of Everglades National Park, USA. Aquatic Conservation: Marine & Freshwater Ecosystems 11:45-57.

Armentano, T.V., J.P. Sah, M.S. Ross, D.T. Jones, H.C. Cooley and C.S. Smith, 2006. Rapid responses of vegetation to hydrological changes in Taylor Sough, Everglades National Park, Florida, USA. Hydrobiologia 569: 293-309.

Beerens, James M. 2013. CEPP RSM WADEM Spatial Foraging Conditions Model Output: "WADEM: Wader Distribution Evaluation Modeling". Department of Biological Sciences Florida Atlantic University, Boca Raton, Florida. Report Submitted to U.S. Army Corps of Engineers, 11 March 2013, Cooperative Agreement Number: W912HZ-10-2-0024.

Bennetts, R.E., P.C. Darby, and L.B. Karunaratne. 2006. Foraging patch selection by snail kites in response to vegetation structure and prey abundance and availability. Waterbirds 29(1):88-94.

Bernhardt, C.E. and D.A. Williard. 2006. Marl prairie vegetation response to 20th century hydrologic change. U.S. Geological Survey Open-File Report 2006-1355. U.S. Geological Survey, Eastern Earth Surface Processes Team, 926A National Center, Reston, Virginia, Florida.

Brandt, 2013. An Evaluation of Central Everglades Planning Project (CEPP) alternatives using an Index of the crocodile Habitat Suitability Index. U.S. Fish and Wildlife Service, Davie, Florida.

Brandt, L.A. and F.J. Mazzotti. 2000. Nesting of the American alligator (*Alligator mississippiensis*) in the Arthur R. Marshall Loxahatchee National Wildlife Refuge. Florida Field Naturalist. 28(3):122-126.

Browder, J. A., V. R. Restrepo, J. Rice, M. B. Robblee, Z. Zein-Eldin. 1999. Environmental influences on potential recruitment of pink shrimp, *Farfantepenaeus duorarum*, from Florida Bay nursery grounds. Estuaries 22(2B):484-499.

Browder, J.S., P.J. Gleason, and D.R. Swift. 1994. Periphyton in the Everglades: spatial variation, environmental correlates, and ecological implications. Pages 379-418, *in* Everglades: The Ecosystem and Its Restoration, S.M. Davis and J.S. Ogden (Eds.). St. Lucie Press, Delray Beach, Florida, USA.

Catano, C. and J. Trexler. 2013. CEPP model comparison of predicted freshwater fish densities, Draft 3.0. Comprehensive Everglades Restoration Plan, Restoration Coordination and Verification (RECOVER). U.S. Army Corps of Engineers Jacksonville District, Jacksonville, Florida, and South Florida Water Management District, West Palm Beach, Florida.

Chaing, C., C.B. Craft, D.W. Rogers, and C.J. Richardson. 2000. Effect of 4 Years of Nitrogen and Phosphorus Additions on Everglades Plant Communities. Aquatic Botany 68: 61-78.

Craft, C.B., J. Vymazal, and C.J. Richardson. 1995. Response of Everglades Plant Communities to Nitrogen and Phosphorus Additions. Wetlands 15:258–271.

Craighead, F.C. 1968. The role of the alligator in shaping plant communities and maintaining wildlife in the southern Everglades. Fla. Nat., 41:2-7, 69-74, 94.

Curnutt, J.L., A.L. Mayer, T.M. Brooks, L., Manne, O.L., Bass Jr., D.M. Fleming, D.M., M.P. Nott, and S.L. Pimm, 1998. Population dynamics of the endangered Cape Sable seaside sparrow. Animal Conservation 1, 11–21.

Darby, P.C., 1998. Florida apple snail (*Pomacea paludosa* Say) life history in the context of a hydrologically fluctuating environment. Ph.D. Dissertation. University of Florida, Gainesville, Florida, USA.

Darby, P.C., J. D. Croop, R. E. Bennetts, P. L. Valentine-Darby, and W. M. Kitchens. 1999. A comparison of sampling techniques for quantifying abundance of the Florida apple snail (*Pomacea paludosa*, SAY). Journal of Molluscan Studies 65:195-208.

Darby, P.C., R.E. Bennetts, S. Miller, and H.F. Percival. 2002. Movements of Florida apple snails in relation to water levels and drying events. Wetlands 22(3): 489-498.

Darby, P.C., R.E. Bennetts, and H. F. Percival. 2008. Dry down impacts on apple snail (*Pomacea paludosa*) demography: implications for wetland water management. Wetlands 28(1): 204-214.

Davis, J. H., Jr. 1943. The natural features of southern Florida: Especially the vegetation and the Everglades. Geol. Bull. #25. Fla. Geol. Survey, Tallahassee.

Davis, S.M., L.H. Gunderson, W.A. Park, J.R. Richardson, and J.E. Mattson. 1994. Landscape dimension, composition, and functioning in a changing Everglades ecosystem. Pages 419-444, *in* Everglades: The Ecosystem and Its Restoration, S.M. Davis and J.C. Ogden (Eds.), St. Lucie Press, Delray Beach, Florida, USA.

Davis, S.M. and J.C. Ogden, 1997. Everglades: the Ecosystem and its Restoration. St. Lucie Press, Delray Beach, Florida, USA.

Doren, R.F., J.C. Volin and J.H. Richards. 2009. Invasive exotic plant indicators for ecosystem restoration: An example from the Everglades Restoration Program. *Ecological Indicators*, 9S:S29-S36.

Duellman, W.E., and A. Schwartz. 1958. Amphibians and reptiles of southern Florida. Bulletin Florida State Museum, Biological Science 3:181-324.

Gawlik, D.E., 2002. The effects of prey availability on the numerical response of wading birds. Ecological Monographs 72(3): 329-346.

Gawlik, D. E., G. Crozier, K. H. Tarboton. 2004. Wading bird habitat suitability index. Pages 111-127, *In* K. C. Tarboton, M. M. Irizarry-Ortiz, D. P. Loucks, S. M. Davis, and J. T. Obeysekera. Habitat suitability indices for evaluation water management alternatives. Technical Report, South Florida Water Management District, West Palm Beach, FL.

Gunderson L. 1994. Vegetation of the Everglades: determinants of community composition. Pages 323-340, *in* Everglades: The Ecosystem and Its Restoration, Davis S and Ogden J (Eds.), St. Lucie Press, Delray Beach, Florida, USA.

Joint Ecosystem Modeling 2013. An Evaluation of Central Everglades Planning Project (CEPP) alternatives using the Apple Snail Production Model. U.S. Geological Survey, Southeast Ecological Science Center. Davie, Florida.

Karunaratne, L.B., P.C. Darby and R.E. Bennetts. 2006. The effects of wetland habitat structure on Florida apple snail density. Wetlands 26(4): 1143-1150.

Kushlan, J.A. 1990. Wetlands and wildlife, the Everglades perspective in Freshwater wetlands and Wildlife, R. R. Sharitz and J. W. Gibbons (Eds.), CONF-8603101, DOE Symp. Ser. No. 61, Office of Scientific and Technical Information, U.S. Department of Energy, Oak Ridge Tenn.

Kushlan, J.A. and M.S. Kushlan. 1979. Observations on Crayfish in the Everglades, Florida. Crustaceana. Supplement, No. 5, Studies on Decapoda (Biology, Ecology, Morphology,and Systematics):115-120.

Langeland, K. A. 1996. Hydrilla verticillata (L.F.) Royle (Hydrocharitaceae), "The perfect aquatic weed". Castanea 61(3):293-304.

Lockwood, J.L., M.S. Ross and J.P. Sah. 2003. Smoke on the water: the interplay of fire and water flow on Everglades restoration. Frontiers in Ecology and the Environment 1(9): 462468.

LoGalbo, A., Pearlstine, L., Lynch, J. Alvarado, M. and R. Fennema. 2012. Wood Stork Foraging Probability Index (STORKI v. 1.0). South Florida Natural Resources Conservation Center. Ecosystem Restoration, South Florida Ecosystem Office, Homestead, Florida.

Mazzotti, F.J. 1999. The American Crocodile in Florida Bay. Estuaries 22: 552-561.

Mazzotti, F. J. and L. A. Brandt. 1994. Ecology of the American alligator in a seasonally fluctuating environment. Pages 485-505, *in* Everglades: The Ecosystem and Its Restoration, S. M. Davis and J. C. Ogden (Eds.). St. Lucie Press, Delray Beach, Florida, USA.

Mazzotti , F.J. L.A. Brandt, P.E. Moler and M.S. Cherkiss. 2007. American Crocodile (*Crocodylus acutus*) in Florida: Recommendations for Endangered Species Recovery and Ecosystem Restoration. J. Herp. 41: 121-131.

McCormick, P.V., P.S. Rawlik, K. Lurding, E.P. Smith, and F.H. Sklar. 1996. Periphyton water quality relationships along a nutrient gradient in the northern Everglades. Journal of the North American Benthological Society 15:433-449.

McKelvin, M.R, D.D. Hook, and A. Rozelle. 1998. Adaptation of plants to flooding and soil waterlogging. *In* Southern Forested Wetlands, M.G. Messina and W.H. Conner (Eds.). Lewis Publishers, Boca Raton, Florida, USA.

McVoy, C. W., W. P. Said, J. Obeysekera, J. A. VanArman and T. W. Dreschel. 2011. Landscapes and Hydrology of the Predrainage Everglades. University Press of Florida, Gainesville, Florida, USA.

Moler, P. 1992. American Crocodile population dynamics. Final Report. Study Number: 7532. Bureau of Wildlife Research Florida Game and Fresh Water Fish Commission.

Natural Resource Conservation Service. 2013. http://casoilresource.lawr.ucdavis.edu/drupal/node/902. Web soil survey.

Newman, S., J. Schuette, J. Grace, K. Rutchey, T. Fontaine, and K. Reddy. 1998. Factors Influencing Cattail Abundance in the northern Everglades. Aquatic Biology 60:265-280.

Newman, S., P.V. McCormick, S.L. Miao, J.A. Laing, W.C. Kennedy, and M.B. O'Dell. 2004. The Effect of Phosphorus Enrichment on the Nutrient Etatus of a Northern Everglades Slough. Wetlands Ecology and Management 12:63-79.

Orth, R. J., T. B. Carruthers, W. C. Dennison, C. M. Duarte, J. W. Fourqurean, K. L. Heck, A. R. Hughes, G. A. Kendrick, W. J. Kenworthy, S. Olyarnik, F. T. Short, M. Waycott and S. L. Williams. 2006. A Global Crisis for Seagrass Ecosystems. BioScience 56(12):987-996.

Powers, E. 2005. Meta-stable states of vegetative habitats in Water Conservation Area 3A, Everglades. Thesis, University of Florida, Gainesville, Florida, USA.

RECOVER. 2004. CERP Monitoring and Assessment Plan: Part 1. Monitoring and Supporting Research—January 2004. Comprehensive Everglades Restoration Plan, Restoration Coordination and Verification (RECOVER). U.S. Army Corps of Engineers Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, Florida.

RECOVER. 2009. 2009 System Status Report. Restoration Coordination and Verification Program c/o United States Army Corps of Engineers, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL. September 2010.

RECOVER 2013. Southern Coastal Systems CEPP model comparison. Comprehensive Everglades Restoration Plan, Restoration Coordination and Verification (RECOVER). U.S. Army Corps of Engineers

Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL.

Rich, E. 1990. Observations of feeding by *Pomacea paludosa*. Florida Scientist 53 (supplement):13.

Ross, M.S., J.P. Sah, J.R. Snyder, P.L. Ruiz, D.T. Jones, H. Cooley, R. Travieso and S. Robinson. 2004. Effect of hydrological restoration on the habitat of the Cape Sable seaside sparrow. Annual Report of 2003-2004. Unpublished report to U.S. Army Corps of Engineers, Jacksonville, Florida. Southeast Environmental Research Center, Florida International University, Miami, Florida, USA.

Ross, M.S., J.P. Sah, J.R. Snyder, P.I. Ruiz, D.T. Jones, H. Colley, R. Trabieso and D. Hagayari. 2006. Effect of hydrology restoration on the habitat of the Cape Sable seaside sparrow. Annual report of 2005-2005. Unpublished report to the U.S. Army Corps of Engineers, Jacksonville, Florida. Southeast Environmental Research Center, Florida International University, Miami, Florida.

Rutchey, K. and L. Vilchek. 1994. Development of an Everglades Vegetation Map Using a SPOT Image and Global Positioning System. Photogrammetric Engineering and Remote Sensing 60:767-775.

Sah, J.P., M.S. Ross, J.R. Snyder, P.L. Ruiz, S. Stoffella, M. Kline, B. Shamblin, E. Hanan, D. Ogurcak and B. Barrios. 2008. Effect of hydrological restoration on the habitat of the Cape Sable seaside sparrow. Annual Report of 2006-2007. Report to Everglades National Park, Homestead, FL.

Sah, J. P. 2004. Vegetation structure and composition in relation to the hydrological and soil environments in tree islands of Shark Slough. Chapter 6. In: Ross, M.S., Jones, D. T., Eds. Tree Islands in the Shark Slough Landscape: interactions of vegetation, hydrology and soils. Final Report submitted to Everglades National Park, U.S. Department of the Interior, National Park Service.

Schaefer, J. and J. Junkin. December, 1990. University of Florida, Florida Cooperative Extension Service. Publication SS-WIS-24: The Eastern Indigo Snake: A Threatened Species. Gainesville, Florida.

Sharfstein, B. and A. D. Steinman, 2001. Growth and survival of the Florida apple snail (*Pomacea paludosa*) fed 3 naturally occurring macrophyte assemblages. Journal of the North American Benthological Society: 20(1): 84–95.

Sklar, F. and A. van der Valk, eds. 2002. Tree islands of the Everglades: an overview. Pages. 1-18 *in* Tree Islands of the Everglades. Kluwer Academic Publishers, Dordrecht, The Netherlands.

South Florida Natural Resources Conservation Center. 2013a. An Evaluation of Central Everglades Planning Project (CEPP) alternatives using the Alligator Production Suitability Model. Ecosystem Restoration, South Florida Ecosystem Office, Homestead, Florida.

South Florida Natural Resources Conservation Center. 2013b. An Evaluation of Central Everglades Planning Project (CEPP) alternatives using the Wood Stork Foraging Potential Model. Ecosystem Restoration, South Florida Ecosystem Office, Homestead, Florida.

South Florida Natural Resources Conservation Center. 2013c. An Evaluation of Central Everglades Planning Project (CEPP) alternatives using the Everglades Landscape Vegetation Succession Model. Ecosystem Restoration, South Florida Ecosystem Office, Homestead, Florida.

South Florida Water Management District. 2012. South Florida Environmental Report. Volume 1.

South Florida Water Management District. 2010a. South Florida Environmental Report. Volume 1.

South Florida Water Management District. 2010b. South Dade Wetlands Conceptual Land Management Plan. 2005 – 2010.

Steiner, T.M., O.L. Bass, Jr., and J.A. Kushlan. 1983. Status of the eastern indigo snake in southern Florida National Parks and vicinity. South Florida Research Center Report SFRC83/01, Everglades National Park; Homestead, Florida.

Sykes, P.W., Jr. 1987a. The feeding habits of the Snail Kite in Florida, USA. Colonial Waterbirds 10:84-92.

Sykes, P .W., J. A. Rodgers, and R. E. Bennetts. 1995. Snail Kite (*Rostrhamus sociabilis*). In A. Poole and F. Gill (eds.) The Birds of North America, No. 171. The Academy of Natural Sciences, Philadelphia and the American Ornithologists' Union, Washington, D.C.

Trexler, J. C., Loftus, W. F., Jordan, F., Lorenz, J. J., Chick, J. H., & Kobza, R. M. (2000). Empirical assessment of fish introductions in a subtropical wetland: an evaluation of contrasting views. *Biological Invasions*, *2*(4), 265-277.

Troxler, T.G., and D.L. Childers. 2010. Biogeochemical contributions of tree islands to Everglades wetland landscape nitrogen cycling during seasonal inundation. Ecosystems 13:75-89.

Troxler, T.G. and J.H. Richards. 2009. δ13C, δ15N, carbon, nitrogen and phosphorus as indicators of plant ecophysiology and organic matter pathways in Everglades deep slough, Florida. Aquatic Botany 91: 157-169.

Turner, R. L. 1996. Use of stems of emergent vegetation for oviposition by the Florida apple snail (*Pomacea paludosa*), and implications for marsh management. Florida Scientist 59:34–49.

U.S. Army Corps of Engineers. 2012. Record of Decision. Final Environmental Impact Statement for the Central and Southern Florida Project: Everglades Restoration Transition Plan. U.S. Army Corps of Engineers; Jacksonville, Florida.

U.S. Environmental Protection Agency. 2008. Final Total Maximum Daily Load (TMDL) for Biochemical Oxygen Demand, Dissolved Oxygen, and Nutrients in the Lake Okeechobee Tributaries. USEPA Region 4, Atlanta, GA. June 2008.

U.S. Fish and Wildlife Service. 1986. Everglades snail kite (Rostrhamus sociabilis plumbeus) revised recovery plan. On file at U.S. Fish and Wildlife Service; Atlanta, Georgia.

U.S. Fish and Wildlife Service. 1999. South Florida Multi-Species Recovery Plan. Southeast Region, Atlanta, Georgia, USA.

U.S. Fish and Wildlife Service. 2010. Eco-recommendations for the multi-species schedule. Presentation to the ERTP Team. January 15, 2010. Vero Beach, Florida, USA.

U.S. Fish and Wildlife Service. 2012. Biological Opinion for Everglades Restoration Transition Plan, Phase I. South Florida Ecological Services Office, Vero Beach, Florida, USA.

Van der Walk, A.G., L. Squires, and C.H. Welling, 1994. Assessing the impacts of an increase in water levels on wetland vegetation. Ecological Applications 4: 525-533.

Wetzel, R.G. (Ed.). 1983. Periphyton of Freshwater Ecosystems. W. Junk Publishers, Boston, Massachusetts, USA.

Wetzel, P. R. 2002. Tree island ecosystems of the world. In: Sklar FH, van der Valk AG (eds) Tree islands of the Everglades. Kluwer Academic Publishers, Dordrecht.

Wetzel, P.R., A.G. van der Valk, S. Newman, C.A. Coronado, T.G. Troxler-Gann, D.L. Childers, W.H. Orem, F.H. Sklar. 2009. Heterogeneity of phosphorous distribution in a patterned landscape, the Florida Everglades. Plant Ecology 200:69-82.

Wetzel, P.R., F.H. Sklar, C.A. Coronado, T.G. Troxler, S.L. Krupa, P.L. Sullivan, S. Ewe and S. Newman. 2011. Biogeochemical processes on tree islands in the Greater Everglades: Initiating a new paradigm. Critical Reviews in Environment and Technology 41:670-701.

Wood, J.M. and G.W. Tanner, 1990. Graminoid community composition and structure within four everglades management areas. Wetlands 10(2): 127-149.

Wu, Y., K. Rutchey, W. Guan, L. Vilchek, and F. H. Sklar. 2002. Spatial Simulations of Tree Islands for Everglades Restoration. *In* Tree Islands of the Everglades, F.H. Sklar and A. Van der Valk (Eds.). Kluwer Academic, Dordrecht, Germany.

Zweig, C.L., 2008. Effects of landscape gradients on wetland vegetation. Ph.D. Dissertation. University of Florida, Gainesville, Florida, USA.

Zweig, C.L. and W.M. Kitchens, 2008. Effects of landscape gradients on wetland vegetation communities: information for large-scale restoration. 2008. Wetlands 28(4): 1086-1096.

APPENDIX C.2.2

EFFECTS OF THE RECOMMENDED PLAN

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C.2.2 EFFECTS OF THE RECOMMENDED PLAN

Analysis of Alternatives 1-4 identified Alt 4 as cost effective and the National Ecosystem Restoration (NER) plan to be carried forward for further analysis. This appendix provides a detailed discussion of the potential environmental effects, which can be either positive or negative, that could result from implementation of Alternative (Alt) 4R and Alt 4R2, the recommended plan. The evaluation of alternatives 1 through 4 identified the need to revise the operations of Alt 4 to ensure the project savings clause constraints are met, to minimize localized adverse ecological effects, and to identify additional opportunities to provide for other water related needs. Alternative 4 was initially refined with operational changes to avoid potential impacts to water supply levels of service in the LOSA and LEC, resulting in Alt 4R. Alt 4R was then refined further to determine if water supply cutbacks to the LOSA could be further reduced and to determine the quantity of additional LECSA 2 and LECSA 3 public water supply able to be provided while maintaining the natural system performance realized for Alt 4R. Due to these changes in operations, Alts 4R and 4R2 were no longer comparable to Alts 1-4. Because they are not comparable, they were separated and placed in different matrices. Alternatives 4R and 4R2 were compared to and evaluated against the FWO to describe changes to existing conditions with implementation of each Central Everglades Planning Project (CEPP) action alternative. The evaluation of the effects was based on results of modeling simulations, current information including scientific literature, direct observation, project design reports, reasonable scientific judgment, the scoping process, and other environmental impact statement (EIS) documents for similar projects. The No Action Alternative (for consistency of the report the **No Action Alternative** is referred to as the **Future Without [FWO]** for the remainder of the report), considers the environmental conditions in the affected regions without the Proposed Action and is fully discussed in **Appendix C.1.2**.

The features of the recommended plan are described in **Section 6.1 Description of the Plan** with specific features located in **Figures 6-1** through **6-4**. The recommended plan would decrease the large pulses of Lake Okeechobee water that currently are sent east to the St. Lucie and west to the Caloosahatchee estuaries and send this water southward through Everglades Agricultural Area (EAA) canals to flowage equalization basins (FEB). The FEBs would provide storage capacity, attenuation of high flows, and limited pre-treatment prior to delivery of this redirected water to existing stormwater treatment areas (STAs), which would reduce phosphorus concentrations in the water to meet required water quality standards. The treated water would be distributed across the northwestern boundary of Water Conservation Area (WCA) 3A to flow through and help restore more natural quantity, timing and distribution of waters to WCA 3A, WCA 3B, Everglades National Park (ENP), and Florida Bay. Several existing levees, canals, culverts, and pump stations would be constructed, modified, or removed to improve the flow of water through the system and provide for other water related needs. The recommended plan is referenced throughout the document as Alternative 4R2 (Alt 4R2).

Environmental impacts include both direct and indirect effects. Under the Council on Environmental Quality (CEQ) regulations, direct effects are "caused by the action and occur at the same time and place," while indirect effects are "caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 CFR 1508.8).

C.2.2.1 Climate

The historic climate conditions used in the period of record are assumed to be representative of future scenario climate conditions. South Florida was in a much drier regime from 1965 to the early 1990s

when the Atlantic Multidecadal Oscillation (AMO) transitioned from the cool phase to the warm phase. South Florida experienced more droughts and dry weather during the cool phase, with high-water events (some extreme) being more frequent during the current warm phase. South Florida has been in a "wetter" regime since the early 1990s mostly due to the AMO. With AMO phases lasting typically 20-40 years, the current AMO warm phase has likely peaked. Thus, the generally wetter than normal conditions that Florida has experienced since the early 1990s should begin to slowly decline. After the peak, the warm phase wave will begin its gradual decline where we will see continually cooler anomalies over the next 10-20 years. As we approach the end of the cycle, Florida will experience an increase in dry years compared to wet years. Given the temporal stage of the current phase, conditions will continue to remain wetter than average for the next 10-20 years, but with a slow and gradual decline in intensity until this phase ends and a cool phase begins. However, low frequency dry years can still occur due to other events such as La Niña, which can occur on an average of every 2-7 years. Features of Alts 4R and 4R2 are the same. Implementation of Alts 4R and 4R2 would have a negligible effect on climate within the action area. Minor, localized and less than significant effects to microclimate may occur as a result of redistribution of water and shifts in vegetation. Potential effects may include localized increases in evapotranspiration and temperature changes.

C.2.2.2 Geology and Soils

Features of Alts 4R and 4R2 are the same. On the A-2 footprint, there would be minor and less than significant geologic impacts within the project area from the removal of surface cover (e.g. vegetation and soil), of the caprock from blasting, and removal of limestone to obtain material for construction of levees, canals and roads. Alternatives 4R and 4R2 would result in conversion of relatively flat, uniform agricultural lands to a Flow Equalization Basin (FEB; 4 feet maximum operating depth) and exterior levees up to 10 feet above existing grade (NGVD29).

Improved hydroperiods and sheetflow in Water Conservation Area (WCA) 3A, WCA 3B, and Everglades National Park (ENP) reduce soil oxidation, which promotes peat accretion necessary to rebuild the complex mosaic of habitats across the landscape. On the A-2 footprint, Alts 4R and 4R2 would result in conversion of relatively flat, uniform agricultural lands to a FEB (4 feet maximum operating depth) and exterior levees up to 10 feet above existing grade. Alternatives 4R and 4R2 show an increase in inundation duration over the FWO that will significantly decrease soil oxidation, subsidence and peat fires, providing a minor beneficial effect. Alternatives 4R and 4R2 improve hydrologic conditions in northern WCA 3A in comparison to the FWO by increasing stages and resulting hydroperiods within the area (refer to **Appendix G**, **Table G-22** and **Table G-24**). Inundation duration for Alts 4R and 4R2 ranged from 76% of the period of record to 96% of the period of record in northern ENP (Zone ENP-N) and from 91% to 93% in southern ENP (ENP-S). Inundation duration for the FWO within this same region varied from 78% to 83% of the period of record in northern ENP (Zone ENP-N) and from 86% to 91% in southern ENP (ENP-S). Alternatives 4R and 4R2 produced significantly higher depths than the FWO as depicted by the normalized weekly stage duration curve for IRs 129 (**Figure G-38**) and IR 130 (**Figure G-39**); example IRs for northern (Zone ENP-N) and southern (Zone ENP-S) ENP. Alternatives 4R and 4R2 also consistently improved the number and duration of dry events in Northeast Shark River Slough (NESRS) in comparison to the FWO (**Table G-31**).

C.2.2.3 Vegetation

C.2.2.3.1 Lake Okeechobee

Negligible and less than significant effects to vegetation within Lake Okeechobee's extensive littoral zone are anticipated as a result of implementation of Alts 4R and 4R2. As compared with FWO, Alts 4R

and 4R2 reveal the potential for short-term minor adverse effects to aquatic vegetation due to higher than preferred lake stages. However, the days in which Lake Okeechobee stage exceeded 15.0 feet NGVD occurred approximately 25% of the Period of Record (POR, 1965-2005) in comparison with FWO which occurred approximately 20% of the POR (**Figure C.2.2-52**).

C.2.2.3.2 Northern Estuaries

Currently, many submerged aquatic vegetation (SAV) beds are stressed and have been reduced or eliminated from their former areas by extreme salinity fluctuations, increased turbidity, sedimentation, dredging, damage from boats, and nutrient enrichment which causes algal blooms that, in turn, restrict light penetration. As compared with FWO, Alts 4R and 4R2 show a slight performance improvement within the Northern Estuaries as indicated by fewer high volume flow months and provides a minor beneficial effect. Reduction in high flows and accompanying flow velocities would result in lower suspended solid loading and decreased concentration of colored dissolved organic material, thereby allowing greater light penetration to promote growth of SAV. In addition, reduction in high volume discharge events from Lake Okeechobee would reduce extreme salinity fluctuations associated with such events. Although some seagrasses are tolerant of a wide range of salinity levels, a reduction in high volume discharge events would reduce stress to SAV and aid in long term health of estuarine habitat and biota. Implementation of Alts 4R and 4R2 would help to maintain the target frequency and duration of water releases to the Northern Estuaries and would help curtail continued habitat loss and allow the recovery of more desirable vegetative communities.

C.2.2.3.2.1 Caloosahatchee River Estuary

Alts 4R and 4R2 performed better than FWO, having a fewer number of times flow criteria were not met which would help to re-establish a salinity range favorable to SAV and provides minor beneficial effects. In comparison to FWO, the number of times high flow criteria (>2800 cfs [cubic feet per second]) were not met decreased from 81 for FWO to 70 for Alts 4R and 4R2. The number of times low flow criteria (<450 cfs) were not met decreased from 27 for FWO to 24 and 23 for Alts 4R and 4R2.

C.2.2.3.2.2 St. Lucie Estuary

Compared to FWO, Alts 4R and 4R2 had a fewer number of times flow criteria were not met, which provide minor beneficial effects and benefit oysters and SAV within the estuary and Indian River Lagoon. The number of times high flow criteria were not met (> 2000 cfs) decreased from 65 for FWO to 37 and 36 for Alts 4R and 4R2. The number of times low flow criteria (<350 cfs) were not met decreased from 92 for FWO to 90 for Alt 4R and 65 for Alt 4R2.

C.2.2.3.3 Everglades Agricultural Area

Negligible and less than significant effects to vegetation within the EAA are anticipated as a result of implementation of Alts 4R and 4R2. As all of the property that will be used to construct the A-2 Flow Equalization Basin (FEB) is considered to be atypical jurisdictional wetlands based on hydric soils and hydrology; wetland vegetation is anticipated to return to the site once construction of the A-2 FEB is complete. During construction, temporary short-term adverse effects are expected to vegetation within the construction area, however, these are considered to be minor as the land was formerly used for agriculture.

C.2.2.3.4 Greater Everglades

Due to changes in the quantity, quality, distribution and timing of water entering the Greater Everglades ecosystem, significant effects on wetland hydrology and vegetation would potentially occur with implementation of Alts 4R and 4R2. The primary factors influencing the distribution of dominant freshwater

wetland plant species of the Everglades are soil type, soil depth, nutrients and hydrological regime (FWS 1999). In the Greater Everglades, improved hydroperiods and sheetflow in WCA 2A, WCA 3A, WCA 3B, and Everglades National Park (ENP) result in reduced soil oxidation, promoting peat accretion necessary to rebuild the complex mosaic of habitats across the landscape providing a moderate beneficial effect. Alternatives 4R and 4R2 provide moderate improvements in hydroperiods in WCA 2A compared to FWO. However, Alt 4R had a moderate adverse effect in WCA 2B by significantly decreasing stages compared to FWO, while Alt 4R2 had a minor to moderate adverse effect compared to FWO. In the L-28 Triangle, Alts 4R and 4R2 showed an improvement in hydroperiod over FWO. Slight differences in hydrologic performance among Alts 4R and 4R2 were found within northern WCA 3A, central WCA 3A, WCA 3B and southeastern ENP. Restoration of sheetflow and historic hydropatterns within WCA 2A, WCA 3 and ENP will result in beneficial shifts in vegetation communities, landscape patterns, and animal populations. Implementation of Alts 4R and 4R2 would provide greater project benefits to those areas located in WCA 2A, northern WCA 3A and ENP. Central and southern WCA 3A would remain largely unaffected by the project.

As a result of reduced freshwater inflow and drainage by the Miami Canal, northern WCA 3A is currently dominated largely by mono-specific sawgrass stands, with large areas of shrub and monotypic cattail (*Typha* spp.) stands and lacks the diversity of communities that exists in central and portions of southern WCA 3A. Alts 4R and 4R2 include features to distribute water through spreader canals in the L-4 across northern 3A and backfill portions of the Miami Canal north of Interstate 75, thereby increasing hydroperiods and depths within this area. Implementation of the CEPP is expected to rehydrate much of northern WCA 3A by providing a means for redistributing treated STA discharges from L-4 in a manner that promotes sheetflow and by removing the drainage effects associated with the Miami Canal, thereby providing moderate beneficial effects. Resumption of sheetflow and related patterns of hydroperiod and water depth will significantly help to restore and sustain the microtopography, directionality, and spatial extent of ridges and sloughs and improve the health of three islands in the ridge and slough landscape.

Alts 4R and 4R2 generally produced improved inundation patterns in northwestern WCA 3A, providing minor beneficial effects. Implementation of Alts 4R and 4R2 would achieve 77% of the target HUs for Zone 3A-NW and 70% of the target HUs for Zone 3A-MC. Alt 4R would achieve 75% of the target HUs for Zone 3A-NE. Alt 4R2 would achieve 74% (Refer to **Appendix G**). As compared to Alt 4R, Alt 4R2 produced slightly lower depths during average hydrologic conditions in northeastern WCA 3A. Observed depths for Alt 4R2 in northeastern WCA 3A may be more conducive to shorter hydroperiods sawgrass marshes relative to Alt 4R. Neither Alt 4R nor 4R2 would provide the necessary inundation pattern for slough vegetation restoration; however CEPP implementation of Alts 4R and 4R2 would act to rehydrate northern WCA 3A promoting peat accretion, reducing the potential for high intensity fires and promoting transition from upland to wetland vegetation.

Rehydration of previously dry areas within northern WCA 3A has the potential to temporarily mobilize nutrients within the water column; however, this is not expected to be a significant issue since portions of WCA 3A north of I-75 experience annual dryout and rehydration with no significant downstream impact. One notable concern would be the introduction of phosphorus into previously unimpacted areas (i.e. central and southern WCA 3A) potentially resulting in vegetation shifts, providing a minor adverse effect. Chaing et al. (2000) suggested that phosphorus loadings alter the Everglades plant communities through increased plant productivity, tissue phosphorus storage, soil phosphorus enrichment and shifts in plant species composition. Substantial vegetation changes may result from elevated phosphorus concentrations. Previous studies have shown that slough and sawgrass

communities have been replaced by cattail-dominated communities (Davis et al. 1994; Rutchey and Vilchek 1994; Newman et al. 1998). However, Craft et al. (1995) and Chaing et al. (2000) observed no significant change in macrophyte species diversity or expansion of cattails in study plots receiving nutrient additions during the two years and four years, respectively, of their studies. Vegetation that can assimilate nutrients directly from the water column appears to be the most sensitive to nutrient enrichment and include periphyton and floating-leaved plants, such as spatterdock and water lily (Chaing et al. 2000; Newman et al. 2004). The periphyton-*Utricularia* complex may be quite sensitive to increased phosphorus, as illustrated by the disappearance of this complex from enriched study plots after the third year (Chaing et al. 2000).

Many areas of WCA 3A, particularly within central WCA 3A still contain good quality wetland habitat consisting of a complex of tree islands, sawgrass marshes, wet prairies, and aquatic sloughs. Vegetation and patterning in the central portion of WCA 3A resembles pre-drainage conditions most closely and represents some of the best examples of remnant Everglades habitat in south Florida. As compared to Alt 4R, Alt 4R2 produced slightly higher depths during average hydrologic conditions in central WCA 3A. These areas remain largely unaffected by Alts 4R and 4R2. Increases in depth within central WCA 3A were not as significant as increases in observed depths in northern WCA 3A; however maintenance of existing conditions within this region of the project area is desirable as ridge and slough habitat is well conserved, providing a negligible effect.

In southern WCA 3A, high water levels during the wet season are important in maintaining quality wet prairie and emergent slough habitat (FWS 2010). However, prolonged high water levels (i.e. during both wet and dry season) and extended hydroperiods have resulted in vegetation shifts within southern WCA 3A, negatively impacting tree islands and fragmenting sawgrass ridges, resulting in the loss of historic landscape patterning. Neither Alts 4R, 4R2 nor the FWO would provide significant benefits to southern WCA 3A through reduction in high water levels or duration, therefore, significant shifts in vegetation are not anticipated within this region, providing a negligible effect.

Typical Everglades vegetation, including tree islands, wet prairies, sawgrass marshes, and aquatic sloughs also occur throughout WCA 3B. However, within WCA 3B, the ridge and slough landscape has been severely degraded by the virtual elimination of overland sheetflow due to the L-67 Canal and Levee system. WCA 3B experiences very little overland flow and has become primarily a rain-fed system predominated by shorter hydroperiod sawgrass marshes with relatively few sloughs or tree islands remaining. Loss of sheetflow to WCA 3B has also accelerated soil loss reducing elevations of the remaining tree islands in WCA 3B and making them vulnerable to high water stages.

Improved hydrologic conditions in comparison to FWO within WCA 3B are anticipated through increasing stages and resulting hydroperiods within the area, providing a minor beneficial effect. Increases in stages and hydroperiods would promote wetland vegetation transition, through contraction of sawgrass marshes and expansion of wet prairies, and in deeper regions, sloughs. Plant species diversity will likely increase in WCA 3B with species composition in wet parries determined largely by peat depth and substrate type (Powers 2005). Submerged aquatic plants are commonly associated with sloughs providing structure for growth of periphyton, the main source of primary production within the freshwater Everglades (Gunderson 1994; Powers 2005). As compared to Alt 4R, Alt 4R2 produced slightly higher depths during average hydrologic conditions in northern WCA 3B. Although Alts 4R and 4R2 did not meet the desired dry and wet season water depths for slough vegetation in WCA 3B, CEPP implementation would improve inundation patterns within WCA 3B and slightly improve conditions for slough vegetation relative to the FWO.

Alts 4R and 4R2 include conveyance features and levee removal within L-67A and C, thereby providing new point source discharges of water into WCA 3B and a minor adverse effect. However, it is anticipated that Broward County Water Preserve Areas (BCWPA) CERP Project would be constructed prior to CEPP implementation, thereby reducing discharges from S-9 into L-67A. Currently, Total phosphorous (TP) within L-67A ranges between 10 and 20 ppt, depending upon the time of year. With completion of the BCWPA CERP Project, it is anticipated that TP within L-67A will be greatly reduced and therefore minimal effects to vegetation due to changes in water quality are anticipated within WCA 3B. Cattail expansion will be monitored as outlined within **Annex D, Project Monitoring and Adaptive Management Plan**. Tree islands contain extraordinarily high levels of TP in their soil suggesting that they may play a major role in the biogeochemical cycles of nutrients in the Everglades (Sah 2004; Troxler and Childers 2010; Troxler and Richards. 2009; Wetzel 2002; Wetzel et al. 2009, 2011). Wetzel et al. (2011) found that soil TP levels within WCA 3A and WCA 3B tree islands were approximately 4 times higher than the surrounding marsh TP levels. Tree islands within WCA 3B may help to capture and focus nutrients, assisting to minimize potential effects on sawgrass and wet prairie communities within this region (Wetzel et al. 2011).

Flows through SRS under current system compartmentalization and water management practices are greatly reduced when compared with pre-drainage conditions. The result has been lower wet season depths and more frequent and severe dry downs in sloughs and reduction in extent of shallow water edges. Over-drainage in the peripheral wetlands along the eastern flank of Northeast Shark River Slough (NESRS) has resulted in shifts in community composition, invasion by exotic woody species, and increased susceptibility to fire. Implementation of Alts 4R and 4R2 is expected to rehydrate much of NESRS by providing a means for redistributing flows from WCA 3B to ENP, providing minor beneficial effects. Resumption of sheetflow and related patterns of hydroperiod will significantly help to restore pre-drainage patterns of water depths and the complex mosaic of Everglades' vegetation communities.

As compared with the FWO, Alts 4R and 4R2 produced significantly higher depths and inundation durations in ENP (refer to **Appendix G**, **Figure G-38** and **Figure G-39**). Within northern ENP, performance of Alts 4R and 4R2 was similar with each alternative reducing the number of dry events within Shark River (SRS) and extending average hydroperiods by 35 to 90 days depending upon location. Reduction in number and duration of dry events and extended hydroperiods will reduce soil oxidation, decrease fire potential, promote peat accretion and aid in restoration of historic wetland vegetation communities, providing minor beneficial effects. Improved inundation patterns produced by Alts 4R and 4R2 in northern ENP resulted in better suitability for slough vegetation. Although none of the alternatives met the desired dry and wet season water depths for slough vegetation in northern ENP; Alts 4R and 4R2 would provide benefits as compared with the FWO by increasing water depths in both the wet and dry season within this region. As compared to Alt 4R, Alt 4R2 produced slightly lower depths during average hydrologic conditions in southeastern ENP and decreased overland flow through Taylor Slough. Areas within the eastern marl prairies along the boundary of ENP suffer from over-drainage and reduced water flow.

Alts 4R and 4R2 include increasing capacity at S-333 from 1350 cfs to 3000 cfs. With an increase in S-333 flow, there is a likelihood of increased total phosphorus load entering NESRS. Potential changes in water quality due to implementation of Alts 4R and 4R2 have the potential to have a minor adverse effect on vegetation within ENP. The Everglades, a phosphorus-limited system, historically received most inputs of phosphorus through rainfall, with average TP concentrations of less than 0.01 milligrams per liter (mg/L) (McCormick et al. 1996, Newman et al. 2004). However, more recently, areas within ENP, including NESRS, have been exposed to TP concentrations at or in excess of 0.10 mg/L (SFWMD

2010). These concentrations and any additional inputs resulting from implementation of any of the CEPP alternatives (refer to **Section 5.2.9, Water Quality** for details), have the potential to result in vegetation changes within NESRS. Vegetation that can assimilate nutrients directly from the water column appears to be the most sensitive to nutrient enrichment and include periphyton and floating-leaved plants, such as spatterdock and water lily (Chaing et al. 2000; Newman et al. 2004). Chaing et al, 2000 demonstrated that the periphyton-*Utricularia* complex may be quite sensitive to increased phosphorus, as illustrated by the disappearance of this complex from enriched study plots after the third year. Potential effects to vegetation and species community composition within NESRS and ENP cannot fully be determined at this time. Water quality within the CEPP action area will continue to be monitored, as described in **Annex D**, to determine any associated changes.

Non-native and invasive plant infestations in the action area may be exacerbated by soil disturbance, increased nutrients, and hydrological modification. Many non-native and invasive species are flourishing in a variety of habitats and are negatively affecting the ecology throughout the Everglades. Non-native and invasive plant species are most frequently encountered in disturbed areas and areas where water quality has been impacted by increased nutrient loads. Construction and hydrological modification under Alts 4R and 4R2 will likely influence the spread and establishment of invasive and native nuisance plant species within the CEPP action area, providing a minor adverse effect. Refer to **Section 5.2.17** and **Appendix C, Section C.2.2.18** for additional information.

The Everglades Landscape Vegetation Succession model (ELVeS) was employed to predict vegetation community change over time in response to changes in environmental conditions (South Florida Natural Resources Center 2013c). The model uses empirically-based probabilistic functions of vegetation community niche space and temporal lags to evaluate expected community response within the model's domain. For this CEPP evaluation, ELVeS was run with nine freshwater marsh/wet prairie communities: (1) open water, (2) open marsh, (3) floating emergent marsh, (4) sawgrass, (5) spikerush, (6) marl prairie, (7) cattail, (8) pineland, and (9) wet scrubland. Results of this analysis are illustrated in **Figure C.2.2-1**. **Figure C.2.2-1** displays the dominant vegetation communities selected by ELVeS at the end of the 41-year POR (2005). At the broad landscape scale there are few large community changes in most of CEPP regions. The largest change is in 3A-NW where increased water deliveries to northern WCA 3A result in a decreased wet scrubland community and subsequent increase in sawgrass. Effects of the Blue Shanty flowway in WCA 3B and NESRS (ENP-N) are evident in the replacement of sawgrass with floating emergent marsh and open marsh. A modest expansion of the marl prairie community occurs within the northwestern portion of ENP (ENP-N). Deeper water vegetation communities area expected to expand in WCA 3A along the L-67 and L-29 canals (South Florida Natural Resources Center 2013c). Differences between Alts 4R and 4R2 appear relatively negligible. **Figure C.2.2-2** presents the acreage change between the FWO and Alt 4R for each community type.

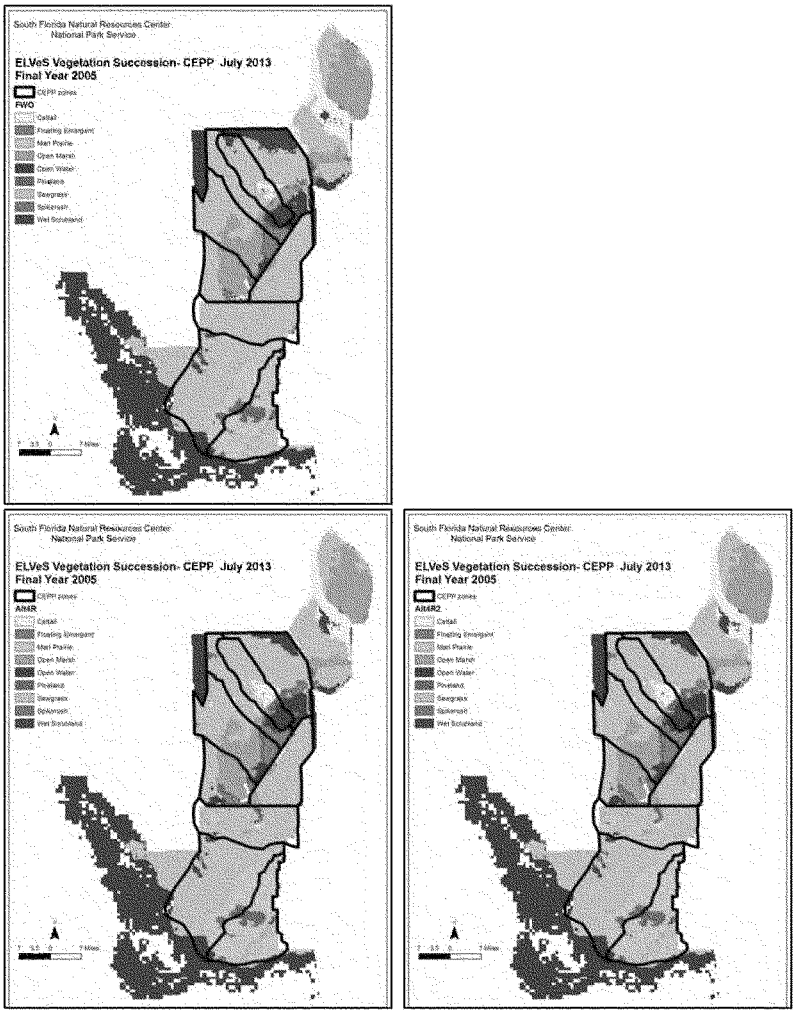


Figure C.2.2-1. Modeled dominant vegetation communities in 2005 as predicted by the Everglades Landscape Vegetation Succession model (ELVeS). The No Action Alternative (FWO) is depicted in the upper panel and Alternatives 4R and 4R2 in the lower panel. (South Florida Natural Resources Center 2013c).

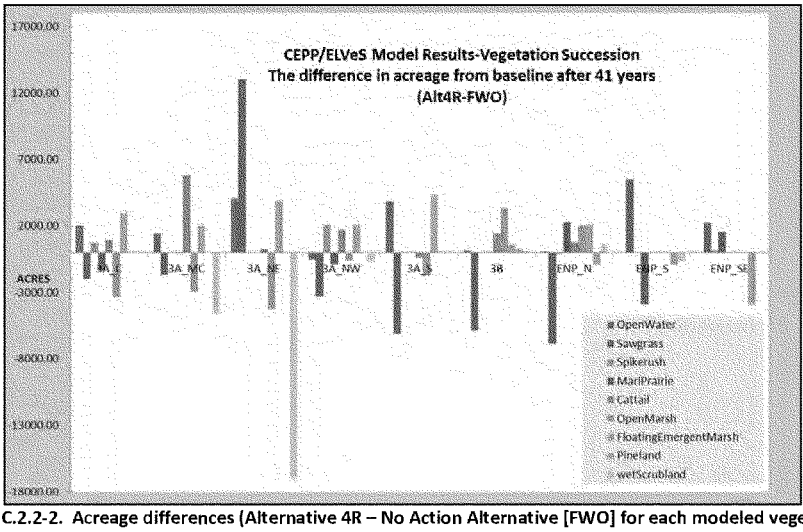


Figure C.2.2-2. Acreage differences (Alternative 4R – No Action Alternative [FWO] for each modeled vegetation community as predicted by Everglades Landscape Vegetation Succession model (ELVeS). (South Florida Natural Resources Center 2013c).

C.2.2.3.4.1 Slough/Open Water Marsh

Deep slough communities formerly occurred throughout the pre-drainage Ridge and Slough region of the Everglades (McVoy et al. 2011). Sloughs within the Greater Everglades have been degraded by compartmentalization resulting in reduced sheetflow, depths and inundation durations, altering vegetation community structure and resulting in expansion of wet prairie and sawgrass marsh communities. Overland sheetflow has been virtually eliminated from WCA 3B due to the L-67 Canal and Levee system, resulting loss of deep water sloughs and dominance of shorter hydroperiod dense sawgrass marsh. Vegetative trends within ENP have also included the conversion of slough/open-water marsh communities to shorter hydroperiod sawgrass marshes (Davis et al. 1994, Davis and Ogden 1997; Armentano et al. 2006). Alts 4R and 4R2 provide significant increases in sheetflow and hydroperiod. As a result of increased flows, depths and durations, it is expected that shorter hydroperiod sawgrass marshes will transition to wet prairie and slough/open water marsh communities providing minor beneficial effects. Shifts from one vegetation type to another may occur in a relatively short time frame (1 to 4 years) following hydrological alteration (Armentano et al. 2006; Zweig 2008; Zweig and Kitchens 2008; Sah et al. 2008). Although Alts 4R and 4R2 do not meet desired dry and wet season water depths for slough vegetation within WCA 3B and ENP; Alts 4R and 4R2 slightly improved conditions for slough vegetation by increasing water depths in both the wet and dry season within these regions.

C.2.2.3.4.2 Sawgrass Marsh

As a result of increased flows, depths and inundation durations, it is expected that shorter hydroperiod sawgrass marshes will transition to slough/open water marsh communities. Increased flow within northern WCA 3A and WCA 3B will aid to reduce dense sawgrass stands and help to promote a mosaic of wetland vegetation types within this area. As compared to Alt 4R, Alt 4R2 produced slightly lower depths during average hydrologic conditions in northeastern WCA 3A. Observed depths for Alt 4R2 in

northeastern WCA 3A may be more conducive to shorter hydroperiods sawgrass marshes, providing minor beneficial effects.

C.2.2.3.4.3 Wet Marl Prairies

Areas within the eastern marl prairies along the boundary of ENP suffer from over-drainage, reduced water flow, exotic tree invasion and frequent human-induced fires (Lockwood et al. 2003; Ross et al. 2006). To alleviate the perpetual drier conditions and its associated problems, increased water flows within this area are required. Alts 4R and 4R2 provide more water to SRS and the southern marl prairies providing minor beneficial effects. Increased hydroperiods within the eastern marl prairies may act to alleviate some of the problems associated with drier conditions and promote a shift in species community composition.

A HSI for marl prairie habitat was employed to predict potential effects of implementation of CEPP Alts 4R and 4R2. The Marl Prairie Indicator is a temporally and spatially explicit modeling tool that simulates hydrologic suitability of marl prairie CSSS habitats based on CSSS survey presence data threshold ranges (Pearlstine et al. 2013). The Marl Prairie Indicator evaluates marl prairie hydrologic suitability with four metrics: (1) average wet season water depths (June – October), (2) dry season water depths (November – May), (3) discontinuous annual hydroperiod (May – April of the next year), and (4) maximum continuous dry days during the nesting season (March 1 – July 15). Suitability for marl prairie habitat for Alts 4R and 4R2 trend similarly. Differences between alternatives within the project area are negligible.

Locations of CSSS subpopulations are depicted in **Figure C.2.2-11**. **Figure C.2.2-3** and **Figure C.2.2-4** display Marl Prairie Indicator results for the following RSM simulations: existing conditions (2012EC), future without CEPP (FWO), CEPP recommended plan (Alt4R2), and CEPP alternative Alt4R. Considered at the scale of all potential sparrow habitats within each subpopulation or habitat area, there were negligible differences between the Alt 4R and Alt 4R2, and we do not discuss these differences further in this document. Hydrologic suitability for marl prairie habitat will transition throughout the southern Everglades, substantially improving in localized regions while notably declining in other regions (**Figure C.2.2-3** and **Figure C.2.2-4**). Alt 4R2 has an overall moderate impact to marl prairie hydrologic suitability in the southern Everglades relative to FWO (**Figure C.2.2-3** and **Figure C.2.2-4**) because of the substantial transitional shifts expected to occur throughout the spatial extent of the southern Everglades. These local differences in performance may warrant further consideration because they illustrate where within the southern Everglades that changes to marl prairie hydrologic suitability are anticipated.

The overall impact to marl prairie hydrologic suitability, when comparing the combined spatial region scores of Alt 4R2 relative to FWO, in Subpopulation A appears relatively neutral. However, there are spatial regions within Subpopulation A where substantial benefits to marl prairie hydrologic suitability occur as well as negative impacts. Hydrologic suitability declines within southeastern and south-central Subpopulation A with Alt 4R2 as well as within the spatial regions flanking the southeastern regions of A. (**Figure C.2.2-4**). Benefits are anticipated within northeastern Subpopulation A and the spatial regions flanking the northeastern and northern region east of Subpopulation A due to the improved distribution of water deliveries across the Tamiami Trail associated with Alt4R2 (**Figure C.2.2-4**). **Figure C.2.2-4** illustrates the projected hydrologic unsuitability of habitat in western and most southern portions Subpopulation A, regardless of the alternative being observed. These areas bring down the overall average habitat scores for Subpopulation A.

The overall impact to marl prairie hydrologic suitability of the combined spatial regions within designated Subpopulation B critical habitat with Alt 4R2 relative to FWO appears relatively neutral.

However, there is a limited spatial region within Subpopulation B where there are limited benefits and one spatial region (one RSM cell) where there are limited negative impacts. Limited negative effects also occur between subpopulations B and E with Alt 4R2 due to the increased flow deliveries (**Figure C.2.2-4**).

Substantial benefits to marl prairie hydrologic suitability appear relatively neutral when comparing Alt4R2 to FWO within Subpopulation C (**Figure C.2.2-4**). The overall impact to marl prairie hydrologic suitability of Alt 4R2 relative to FWO of the combined spatial regions within designated Subpopulation D critical habitat appears relatively neutral. However, there are limited spatial regions throughout Subpopulation D where there are negative impacts (**Figure C.2.2-4**).

The overall impact to marl prairie hydrologic suitability of Alt 4R2 relative to FWO of the combined spatial regions within designated Subpopulation E critical habitat appears relatively neutral. However, there are spatial regions within Subpopulation E where there are substantial negative impacts to marl prairie hydrologic suitability. Beneficial effects occur in the southeastern portion of E due to the increased water deliveries that occur in this region with Alt 4R2 (**Figure C.2.2-4**). Declines in hydrologic suitability are pronounced along the regions of E that abut Shark River Slough due to the increased water deliveries that occur in this region with Alt 4R2. However, these shifts within the critical habitat are accompanied by substantial areas of hydrologic improvements to habitat between subpopulations E and C.

The overall impact to marl prairie hydrologic suitability of Alt 4R2 relative to FWO of the combined spatial regions within designated Subpopulation F appears relatively neutral. However, there are spatial regions within Subpopulation F where there are substantial negative impacts as well as other regions with notable improvements in marl prairie hydrologic suitability. Negative effects are projected in the regions between E and F due to the increased water deliveries that occur in this region with Alt 4R2 (**Figure C.2.2-4**). However, the projected habitat in interior regions of F is notably improved with Alt 4R2. Hydrologic suitability for habitat between F and C also improves with Alt 4R2.

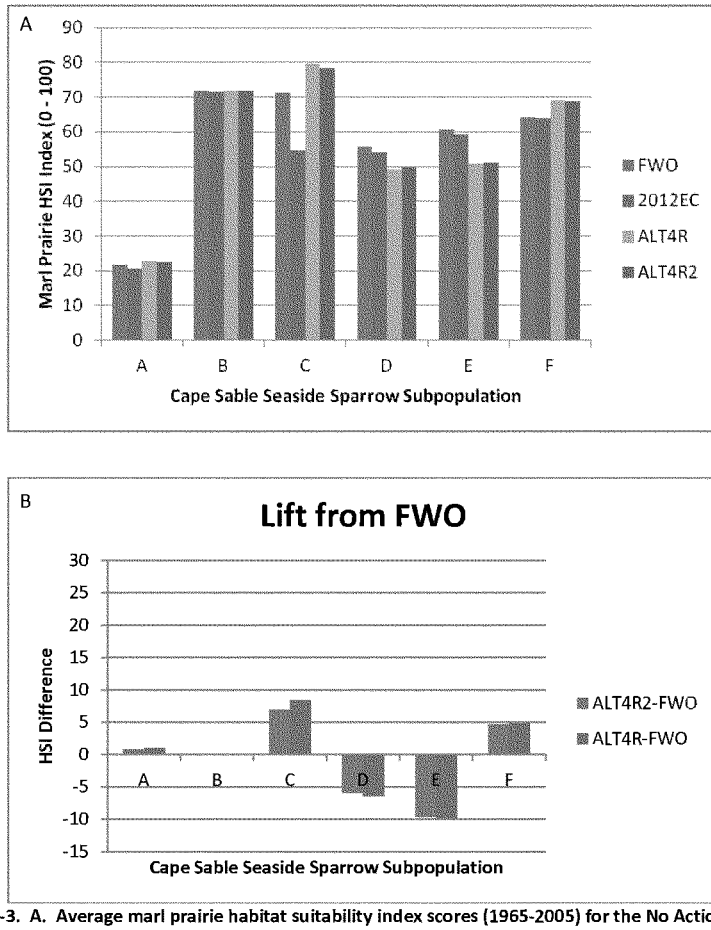


Figure C.2.2-3. A. Average marl prairie habitat suitability index scores (1965-2005) for the No Action Alternative (FWO), existing conditions (2012EC) and Alternatives 4R and 4R2 within CSSS subpopulations A-F. B. Alt4R and Alt4R2 suitable marl prairie habitat (1965-2005) lift from FWO within each CSSS subpopulation. A maximum lift of 100.0 is possible if FWO has an averaged suitability score of 0.0 and the alternative has an averaged suitability score of 100.0.

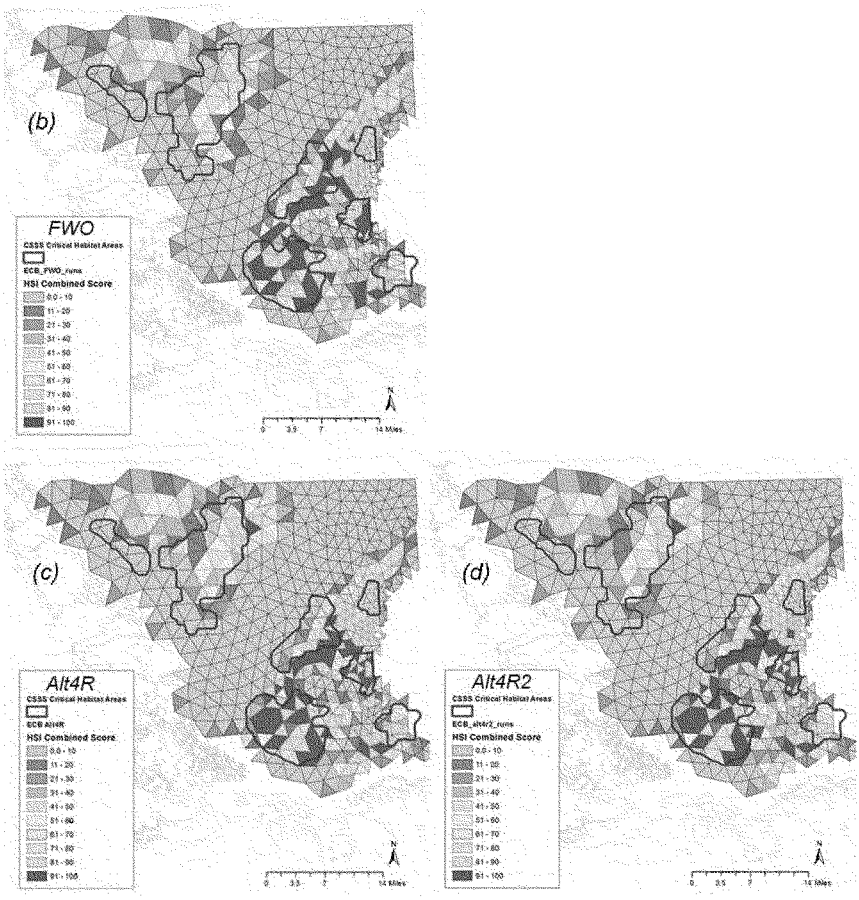


Figure C.2.2-4. Marl prairie habitat suitability for the combined marl prairie indicator scores at each RSM-GL cell for the No Action Alternative and Alternatives 4R and 4R2. Scores range from 0.0 (Not Suitable) to 100 (Most Suitable). CSSS subpopulations are outlined in blue.

C.2.2.3.4.4 Tree Islands

The hydrological and ecological responses of the Greater Everglades to the recommended plan are only slightly different from Alt 4R scenario upon which Alt 4R2 is based. These differences are easily seen when the figures below are compared to their counterparts in **Appendix C.2.1.3.4.4**. Starting in the Northeast section of WCA 3A where there is concern that hydrologic restoration might be stressful for the sawgrass plain and tree islands, the duration curve for ponding depths indicates a significant increase in hydroperiods and depths (**Figure C.2.2-5**). Alts 4R and 4R2 do not alter the extreme high ponding depths that can occur due to extreme meteorological events. Instead it prevents this region from being dry 40% of the time (it will now be dry 15% of the time) and it adds, on average between 0.25 ft. and 0.65 ft. of ponding depth to the stage duration curve, providing minor beneficial effects.

Since water depths on the marsh surface is predicted to be 1.0 ft or less, 80% of the time, this is not considered to be harmful to existing tree islands, Miami Canal islands that will be created, or ghost tree islands that have the potential to be restored by CEPP.

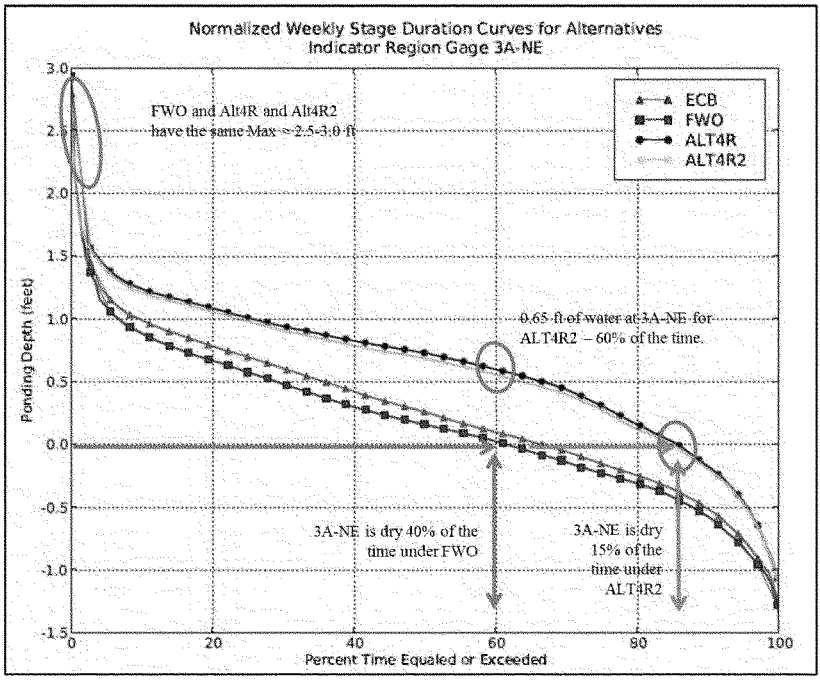


Figure C.2.2-5. The rehydration of Northeastern WCA 3A due to Alt 4R and Alt 4R2.

Moving down through WCA 3A, the central and southern regions are expected to respond similarly. As was seen for the Alts 1-4 evaluations in Southern WCA 3A (Indicator Region 124), Alt 4 managed to lower the ponding depths in comparison to the ECB and improve the ecological condition of trees islands in this region. However, Alts 4R and 4R2 only slightly improve hydrologic conditions for tree islands in comparison to FWO. This was due to the inclusion of the new ERTP schedule in FWO, and that ERTP effectively lowers the potential of flooding stress of trees on trees islands in the most southern reaches of WCA 3A.

Moving into WCA 3B (not including the Blue Shanty Flowway); Alts 4R and 4R2 make significant improvements to the hydroperiods in comparison to the FWO (**Figure C.2.2-6**). Unfortunately, Alts 4R and 4R2 do not do anything to reduce the extreme high ponding depths associated with the FWO. Instead, to prevent soil oxidation on tree islands and in sloughs, Alts 4R and 4R2 increase the hydroperiod in WCA 3B by 10% by adding between 0.2 ft. and 0.5 ft. of ponding depths to the marsh when ponding depths drop below 1 ft, providing minor beneficial effects.

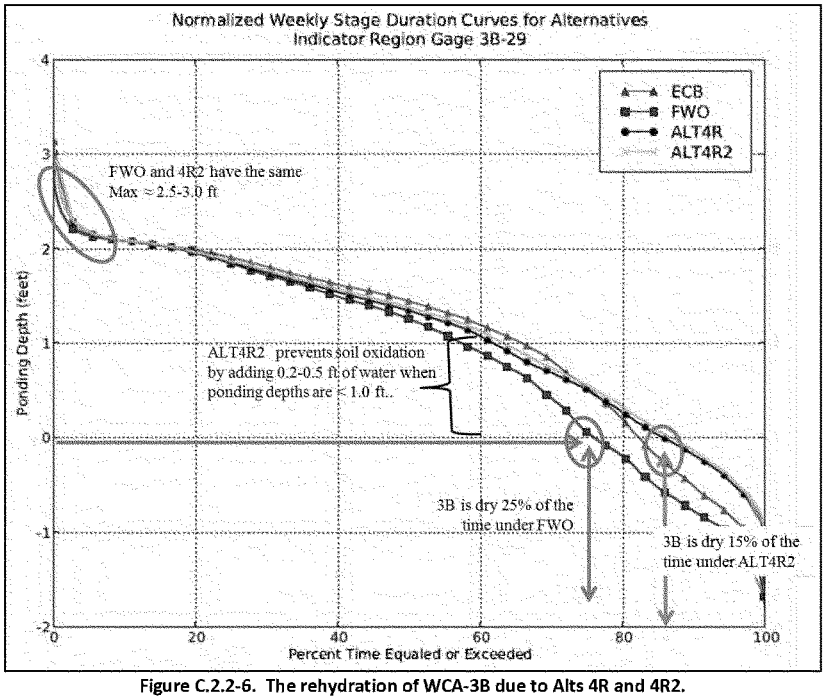


Figure C.2.2-6. The rehydration of WCA-3B due to Alts 4R and 4R2.

Shark River Slough (SRS)

Finally, looking at SRS where tree islands rise high above the surrounding marsh, their potential for flooding stress is practically non-existent. Instead, ENP is faced with a reduction in islands due to intensive fires that migrate across the marshes and burn tree island peat soils so that all that is left are rocky outcroppings. Here the objective of Alts 4R and 4R2 is to prevent extensive dry-downs and create extended hydroperiods. **Figure C.2.2-7** shows a FWO marsh surface hydrology that is shallow and for the most part, is less than 1.0 deep. For tree islands that are 1-2 ft higher than the marsh, this means that they are dry for most of the year. By adding 0.4 ft. of depth to the duration curve in SRS, Alts 4R and 4R2 decrease the probability of peat oxidation on these tree islands by increasing their hydroperiod by 30-40%.

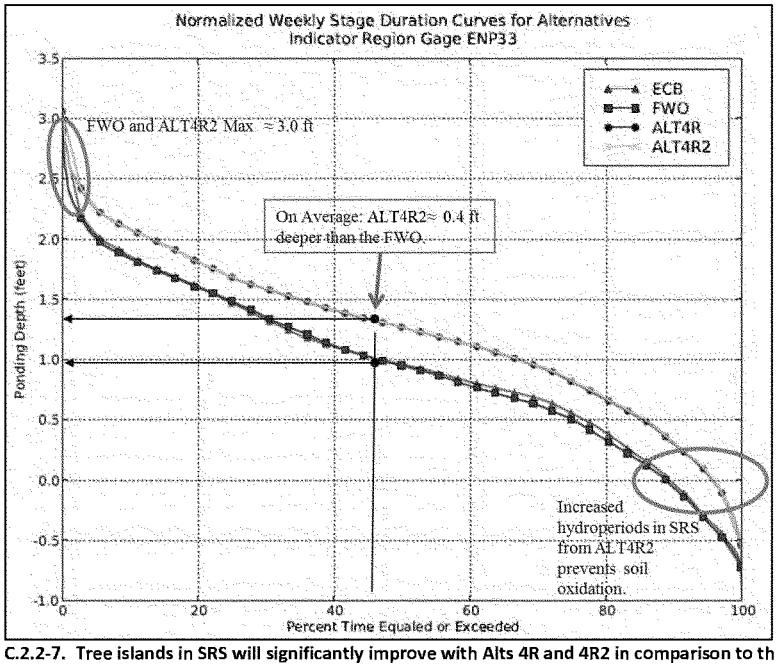


Figure C.2.2-7. Tree islands in SRS will significantly improve with Alts 4R and 4R2 in comparison to the FWO because the recommended plan adds about 0.4 ft. of ponding depths to the entire stage duration curve and because it increases the marsh hydroperiod by about 10%.

Changes in tree island vegetation are possible with Alt 4R2, however, tree island vegetation changes naturally over time and would continue to change under existing conditions or the recommended plan. Such changes are sometimes referred to as 'ecosystem succession' or 'forest dynamics', which are ecological terms that refer to plants colonizing an area or an island and completing their life cycle there while additional species of plants or the next generation of plants compete for space in the same area. This process is accelerated when some of the plants die or topple over, such as when wind storms topple trees which creates openings for seedlings and young plants to grow. Tree falls are a natural and important component of forest dynamics and can happen due to age, wind, trees growing in a site where they are ill-suited, and insect infestation. In the present day Everglades, canal construction and drainage have led to increased drought intensity and a resultant loss of peat soils. Reducing total water quantity stored by the ecosystem has lengthened the dry seasons and increased the frequency and duration of dry down events resulting in increased rates of organic soil loss. Peat loss can contribute to tree falls as a result of poor rooting conditions. It is possible that CEPP hydrology, which is expected to change flows and hydroperiods to be more like the pre-drainage Everglades and more like restoration conditions envisioned in CERP, will stress the root systems of plant species that are not well-suited to live in the restored conditions but are present currently due to drier post-drainage conditions. To address this possibility, CEPP aims for incremental hydrology targets to provide opportunities for the ecosystem, including plant and tree species, to transition to the restored conditions. Monitoring is described in the Adaptive Management and Monitoring Plan (**Annex D**) to check the survival and transition of plant species in key areas in the Everglades and report the results to decision makers.

It should be noted that south Florida's forest dynamics are driven significantly by hurricanes and wind storms. Damage to tree island species can be caused by hurricanes, depending on many factors: the location of tree islands in relation to a hurricane's center, sustained winds and wind gusts speed, soil conditions and types of vegetation. The intensity of a hurricane including duration and precipitation immediately prior to and during the event affect the stability of trees. If winds exceed the resistance of root/soil systems, trees uproot (Mitchell 2013). "In general, taller and larger trees are more susceptible to wind damage than shorter, smaller trees (Merry et al. 2011)." Also, tree species type affects vulnerability to damage (Barry et al., 1998). Therefore while CEPP hydrologic conditions may incrementally stress some plant species it is expected that the natural changes of forest dynamics, especially those associated with Florida's storms, would take place in the future with or without the recommended plan. In addition it is expected that the incremental restoration targets of CEPP and the monitoring feedback that will be provided by the Adaptive Management and Monitoring Plan (**Annex D)** will provide a double-check to ensure that vegetation is adapting to restoration conditions.

C.2.2.3.4.5 Rockland Pine Forest

Negligible and less than significant effects are predicted within Rockland pine forest as a result of CEPP implementation.

C.2.2.3.4.6 Tropical Hardwood Hammock

Tropical hardwood hammocks on the Miami Rock Ridge have been affected by a lowered water table associated with the reduction of freshwater flow through the Everglades. Since Alts 4R and 4R2 provide increased flow through the Greater Everglades, it is anticipated that tropical hardwood hammocks would show a minor beneficial effect from CEPP implementation. As with other vegetative communities, Alts 4R and 4R2 would provide rehydration benefits to ENP as compared with the FWO.

C.2.2.3.5 Southern Coastal Systems

C.2.2.3.5.1 Mangroves

The estuarine communities of Florida Bay have been affected by upstream changes in freshwater flows through the Everglades. A reduction in freshwater inflows into Florida Bay and alterations of the normal salinity balance have affected mangrove community composition and may have contributed to a large-scale die-off of seagrass beds (FWS 1999). Mangrove communities occur within a range of salinities from 0 to 40 practical salinity units (psu).

Florida Bay experiences salinities in excess of 40 psu on a seasonal basis. As compared with FWO, Alts 4R and 4R2 provide increased freshwater flows to Florida Bay and the southwest coastal estuaries, thereby aiding to lower salinities levels within these areas to better encompass mangrove salinity tolerance range and providing minor beneficial effects. Alt 4R2 provides slightly improved salinity conditions in Florida Bay in comparison to Alt 4R and a significant effect.

In Biscayne Bay, Alt4R provided less water while Alt4R2 provided additional flows when compared to FWO. Alt4R flows to the coast are not evenly distributed showing positive benefits in the very northernmost reach of Biscayne Bay and negative effects from the mid-section of the northern portion to the south. Alt4R2 provides additional flows throughout the bay and is likely to provide a minor beneficial effect to the mangrove communities by providing additional flows to the coast, thereby lowering salinity levels and/or reducing the number of days salinities exceed 40 psu. Alt4R would likely result in a minor adverse effect to the mangrove communities by increasing the likely hood of maintaining salinity conditions in Biscayne Bay above the preferred salinity range of mangroves for

longer periods of time than FWO. Alternative 4R shows an unfavorable seasonal flow pattern with reductions in flows compared to FWO generally greater during the dry season. Alt4R2 shows slightly increased flows patterns for both seasons compared to FWO.

C.2.2.3.5.2 Seagrass Beds

Seagrasses within Florida Bay have long suffered from high salinities due to long-term reductions of freshwater flow. Seagrasses have an optimum salinity range of 24 to 35 psu, but can tolerate considerable short-term salinity fluctuations.

As compared with the FWO, Alts 4R and 4R2 provide increased freshwater flows to Florida Bay and the southwestern coastal estuaries, thereby aiding to lower salinities levels within these areas to better encompass seagrass salinity tolerance range and providing minor beneficial effects. Alt 4R2 provides slightly improved salinity conditions in Florida Bay in comparison to Alt 4R.

In Biscayne Bay, Alt4R provided less water while Alt4R2 provided additional flows when compared to FWO. Alt4R flows to the coast are not evenly distributed showing positive benefits in the very northernmost reach of Biscayne Bay and negative effects from the mid-section of the northern portion to the south. Alt4R2 provides additional flows throughout the bay and is likely to provide a significant benefit to the seagrass beds by providing additional flows to the coast, thereby lowering salinity levels and/or reducing the number of days salinities exceed 40 psu having a minor beneficial effect. Alt4R would likely result in a negative effect to the seagrass beds by increasing the likely hood of maintaining salinity conditions in Biscayne Bay above the preferred salinity range of seagrass for longer periods of time than FWO. Alternative 4R shows an unfavorable seasonal flow pattern with reductions in flows compared to FWO generally greater during the dry season. Alt4R2 shows slightly increased flows patterns for both seasons compared to FWO.

C.2.2.4 Threatened and Endangered Species

Regional Simulation Model – Glades Lower East Coast Service Area (RSM-GL) model results were used to compare performance of Alts 4R and 4R2 in relation to the ERTP PMs and ETs on species (discussed in Section 5 and C.2.1) the Corps has determined may be affected by the project. Microsoft Excel 2007 was used to analyze RSM results and create bar graphs to graphically compare Alts 4R, 4R2 and FWO. All calculations are based upon the RSM 41-year POR from 1965 through 2005. A detailed comparison between the Existing Conditions Baseline (2012), the FWO, and Alternative 4R2 (recommended plan) is contained within the Corps CEPP Biological Assessment, located in **Annex A**. A detailed discussion of species under the NMFS purview is contained within the Corps CERP Programmatic Biological Assessment prepared for NOAA NMFS, located in Annex A. A Programmatic Biological Opinion was prepared by USFWS. The Corps entered formal consultation with USFWS on the Everglade snail kite (*Rostrhamus sociablis plumbeus*), and its designated critical habitat, Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*), (CSSS) and its designated critical habitat, wood stork (*Mycteria americana*) and eastern indigo snake (*Drymarchon corais couperi*). The preliminary conclusion is that the proposed project is not likely to jeopardize the continued existence of the species listed above and are not likely to adversely modify critical habitat, where designated. The Programmatic Biological Opinion concurred on the Corps' determination of may affect, but not likely to adversely affect the Florida panther (*Puma concolor coryi*), West Indian manatee (*Trichechus manatus*), and its critical habitat, American crocodile (*Crocodylus acutus*) and its critical habitat, deltoid spurge (*Chamaesyce deltoidea* ssp. *deltoidea*), Garber's spurge (*Chamaesyce garberii*), Small's milkpea (*Galactia smallii*), and tiny polygala (*Polygala smallii*). Furthermore, the Service concurred with all the "No Effect" determinations made by the Corps in regard to the applicable threatened or endangered species that

are found in the action area. The National Marine Fisheries Service (NMFS) provided a Programmatic Biological Opinion for the Comprehensive Everglades Restoration Plan to the Corps on 17 December 2013 and concurred with the "No Effect" determinations for CEPP for the species under their purview.

C.2.2.4.1 Everglade Snail Kite

Evaluation of potential effects to Everglade snail kites within the CEPP project area included adaptations of ERTP PMs, including depth and recession rate requirements for apple snails (FWS MSTS WCA 3 gages **Figure C.2.2-8**), along with the Apple Snail Population Model (SFNRC 2013b). The USACE believes the snail kite metrics (PM-B) are too restrictive, thus deferring to only the apple snail PM as an appropriate assessment that is based upon published literature (Darby 1998-2008).

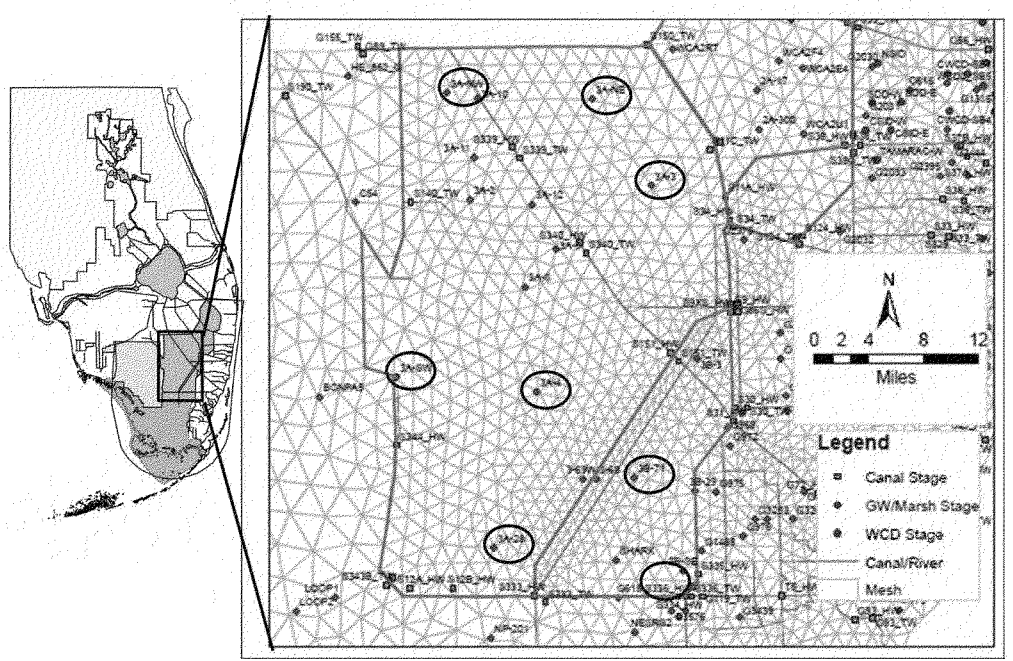


Figure C.2.2-8. WCA 3 Gage Locations for Snail Kite and Apple Snail Performance Measures

As compared to the FWO, rehydration and vegetation shifts within northern WCA 3A and increased hydroperiods within WCA 3B and ENP would increase suitable habitat for apple snails, thereby increasing the spatial extent of suitable foraging opportunities for snail kites, providing a moderate beneficial effect (**Table C.2.2-1.**). Alternatives 4R and 4R2 substantially increased the number of years met over the FWO between May and June except at 3A-28. However, there was not much change between Alternatives 4R and 4R2 and FWO for the December 31 pre-breeding except at 3A-NW.

Table C.2.2-1. Number of years water depths at WCA 3 gages are within the FWS MSTS recommended apple snail depth ranges (PM C).

	31-Dec			May 1- June 1		
	ALT-4R	ALT-4R2	FWO	ALT-4R	ALT-4R2	FWO
Gage	3A-NE					
# years met	0	0	0	21	20	2
Gage	3A-NW					
# years met	17	16	0	17	19	4
Gage	3A-3					
# years met	10	10	11	21	20	7
Gage	3A-4					
# years met	24	22	22	23	23	18
Gage	3A-28					
# years met	4	4	5	17	15	19
Gage	3A-SW					
# years met	0	0	2	31	31	37
Gage	3B-71					
# years met	6	6	5	28	28	5
Gage	3BS1W1					
# years met	24	21	18	17	17	13
Total	**85**	**79**	**63**	**175**	**173**	**105**

An apple snail population model was developed by Phil Darby (University of West Florida), Don DeAngelis (USGS), and Stephanie Romañach (USGS) and is being used as an Ecological Planning Tool for the CEPP. The purpose of the model is to describe the dynamics of the apple snail population a function of hydrology and temperature. The numbers and size distribution of the snails are simulated and can be calculated for any day of a year with input data. Information regarding the size-structured population model was used to simulate the response of apple snails for Alt 4R with FWO and Alt 4R2 with FWO (**Figure C.2.2-9** and **Figure C.2.2-10**, respectively). Conditions are presented for a dry year for each model run (Alt 4R and FWO, and Alt 4R2 and FWO), because dry years are typically when restoration projects are likely to have the biggest impact, given that the system is largely rainfall driven in the wet season. Results are also shown for adult snails (> 20 mm) during the spring of a dry year, before that years' reproductive period. Adult snails during a given year are a product of egg production, and thus environmental conditions, from the previous year. End of spring results are shown as the population of snails of the size class consumed by the endangered Everglades snail kites. Based upon the results of this

analysis, Alt 4R and Alt 4R2 provide better conditions for apple snail populations as compared to the FWO, particularly in WCA 3A, WCA 3B, and ENP and provide a moderate and significant beneficial effect.

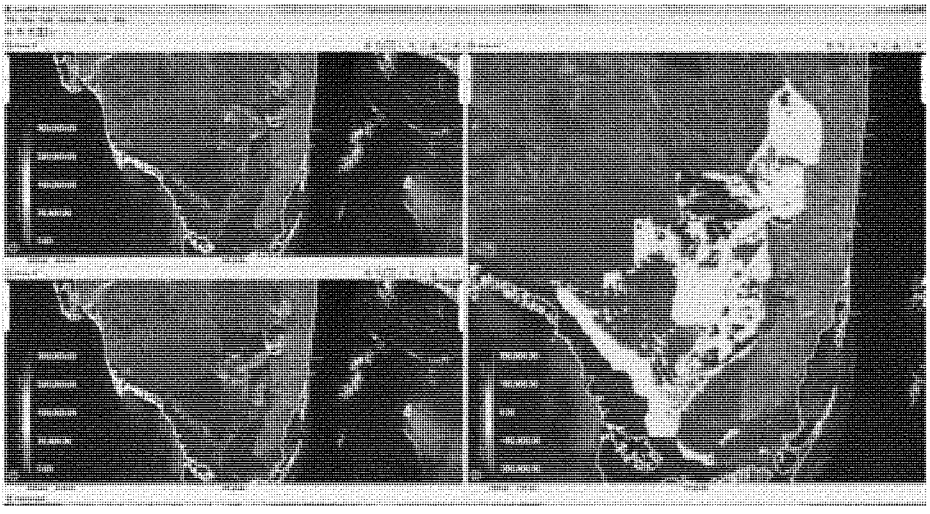


Figure C.2.2-9. Adult snail (> 20 mm) population size as a result of Alt 4R (top left) vs. FWO (bottom left), and a difference map (right map panel) of Alt4R minus FWO. (ENP 2013)

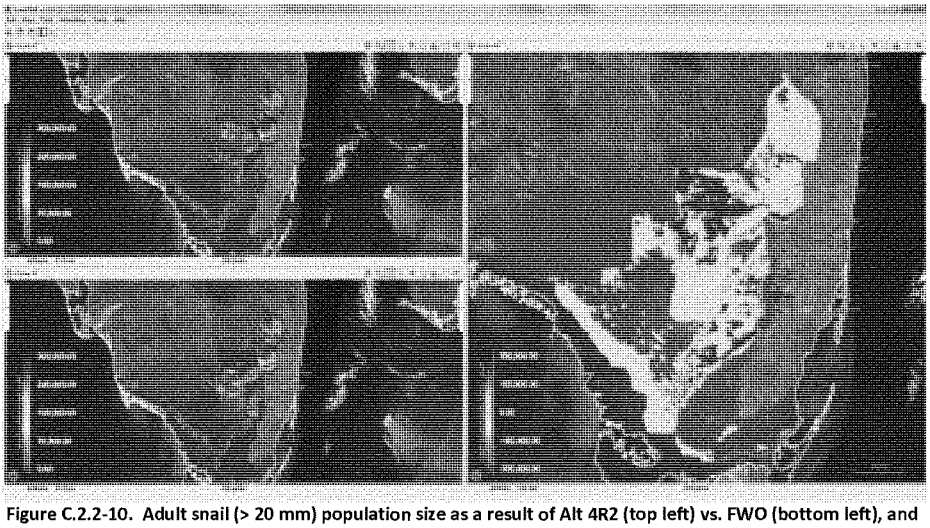
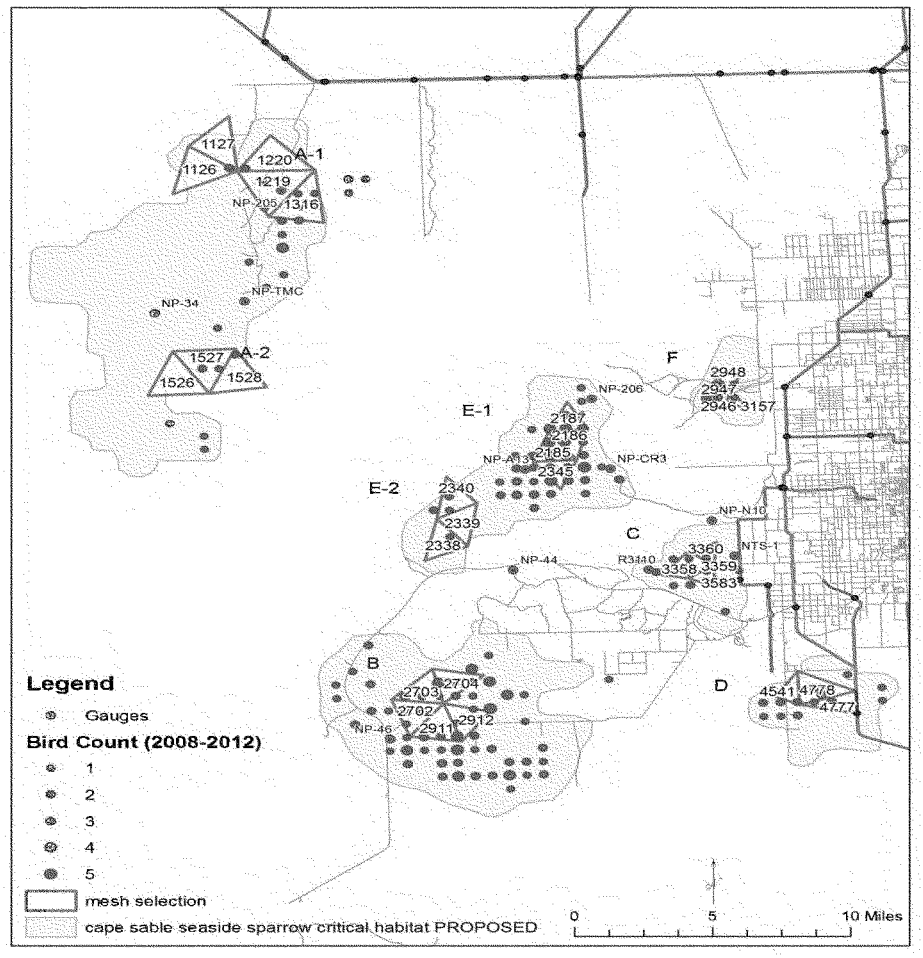


Figure C.2.2-10. Adult snail (> 20 mm) population size as a result of Alt 4R2 (top left) vs. FWO (bottom left), and a difference map (right map panel) of Alt4R2 minus FWO. (ENP 2013).

C.2.2.4.2 Cape Sable Seaside Sparrow

Presently, the known distribution of the CSSS is restricted to two areas of marl prairies east and west of SRS in the Everglades region (within ENP and BCNP) and the edge of Taylor Slough in the Southern Glades Wildlife and Environmental Area in Miami-Dade County. CSSS surveys resulted in a range map that divided the CSSS into six separate subpopulations, labeled as A through F (**Figure C.2.2-11**), with CSSS-A as the only subpopulation west of SRS (Curnutt et al. 1998).

Effects of Alternatives 4R and 4R2 on the CSSS are discussed below based on the appropriate PM and ET.



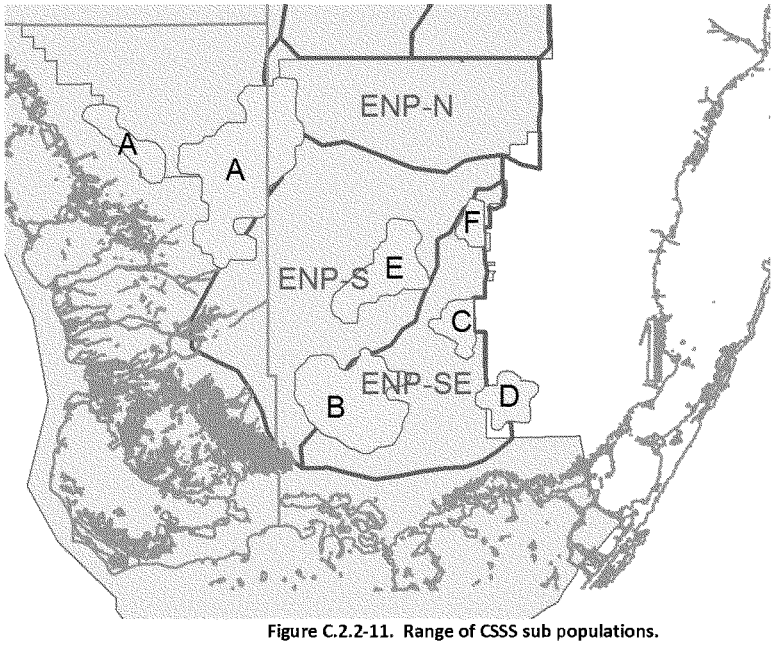


Figure C.2.2-11. Range of CSSS sub populations.

PM-A NP-205 (CSSS-A): Provide a minimum of 60 consecutive days at NP-205 below 6.0 feet, NGVD beginning no later than March 15.

Cape Sable seaside sparrows build nests low to the ground around 14-17 cm. Male CSSS call for mates and set up territories when water levels drop below ground surface. Breeding behavior can be interrupted when water levels rise above ground surface. That is why it is important to maintain water levels below the ground surface for at least 60 days during the nesting season from March 1 to July 15. In order to compare alternatives in relation to PM-A, the RSM-GL simulated NP-205 daily stage was utilized. From this data, the annual discontinuous hydroperiod (number of days inundated), was calculated and the number of consecutive dry days within the CSSS nesting window of March 1 through July 15 counted. **Table C.2.2-2** and **Figure C.2.2-12** compare Alternatives 4R and 4R2 with FWO for 60 consecutive dry days at NP-205 between March 1 and July 15. Alternatives 4R and 4R2 perform better than the FWO in the northern subpopulation A (22 years met compared to 20 in FWO) and show a minor beneficial effect. Alternatives 4R and 4R2 perform the same as the FWO in subpopulations B, C and F and show a negligible effect. Alternatives 4R and 4R2 perform worse than the FWO in the southern Sub population A (26 years met in Alt 4R and 25 years met in Alt 4R2 compared to 33 in the FWO), in subpopulation D (20 years met in Alts 4R and 4R2 compared to 22 in FWO) and subpopulation E (33 years met in Alts 4R and 4R2 compared to 36 in FWO) and show a minor adverse effect.

Table C.2.2-2. PM-A number of years there is a minimum of 60 consecutive days at NP-205 below 6.0 feet, NGVD beginning no later than March 15.

Subpopulation	Gage/Cell	Alt 4R	Alt 4R2	FWO
A	IR-A1	22	22	20
	IR-A2	26	25	33
	P34	29	29	29
	TMC	29	29	32
B	CY3	40	40	40
C	R3110	39	39	39
	E112	38	38	38
D	EVER4	20	20	22
E	NE of NPA13	33	33	36
F	NE of RG2	33	33	33

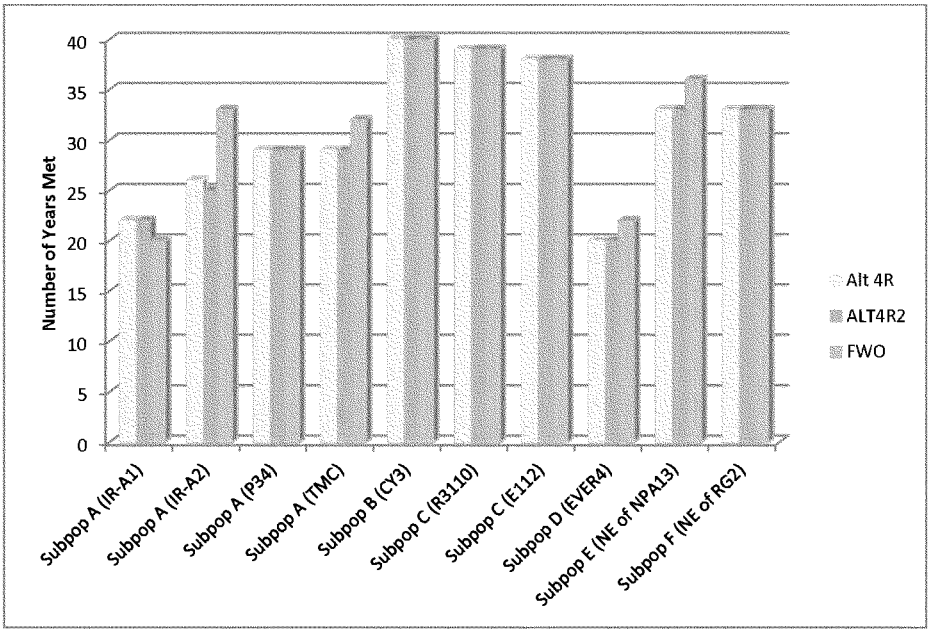


Figure C.2.2-12. PM-A: number of years a minimum of 60 consecutive days at NP-205 below 6.0 feet, NGVD beginning no later than March 15 is met out of the 40 year period of record.

Cape Sable seaside sparrows are largely sedentary, occupy the prairie habitats year-round and are completely dependent on the condition of the prairies. The CSSS have a short life expectancy of two to three years. This short life expectancy range identifies that for the population to sustain itself, there must not be three or more years in a row where water depths are not suitable for nesting. This means that there should not be three consecutive years in a row where the minimum of 60 consecutive dry days during the nesting season is not met. Additional analysis shows the number of consecutive dry days during the nesting season over the POR with the red line indicating 60 days (**Figure C.2.2-13** through **Figure C.2.2-19**). The target is 60 or more consecutive dry days during the nesting season (March 1-May 15) for Alts 4R, 4R2 and FWO and no more than two years in a row. The northern sub population A (A-1), sub population B and sub population C show very little difference between Alt 4R, 4R2 and FWO over the POR (**Figure C.2.2-13**, **Figure C.2.2-15** and **Figure C.2.2-16**). The southern sub population A (A-2) shows three times over the POR where Alts 4R and 4R2 are below the target of 60 consecutive dry days during the nesting season for three years in a row, whereas FWO does not go below the target for three consecutive years over the POR (**Figure C.2.2-14**). Sub population D shows three times over the POR where Alts 4R and 4R2 are below the target of 60 consecutive dry days during the nesting season for three years in a row, whereas FWO is below the target for three consecutive years one time over the POR (**Figure C.2.2-17**). In sub pop E, Alts 4R and 4R2 drop below the target of 60 consecutive dry days during the nesting season more times than the FWO, however neither the Alts nor FWO are below the target for three consecutive years over the POR (**Figure C.2.2-18**). In sub pop F, Alts 4R and 4R2 perform better than the FWO and do not go below the target of 60 consecutive dry days during the nesting season for three years in a row, whereas FWO goes below the target range for three years in a row over the POR (**Figure C.2.2-19**).

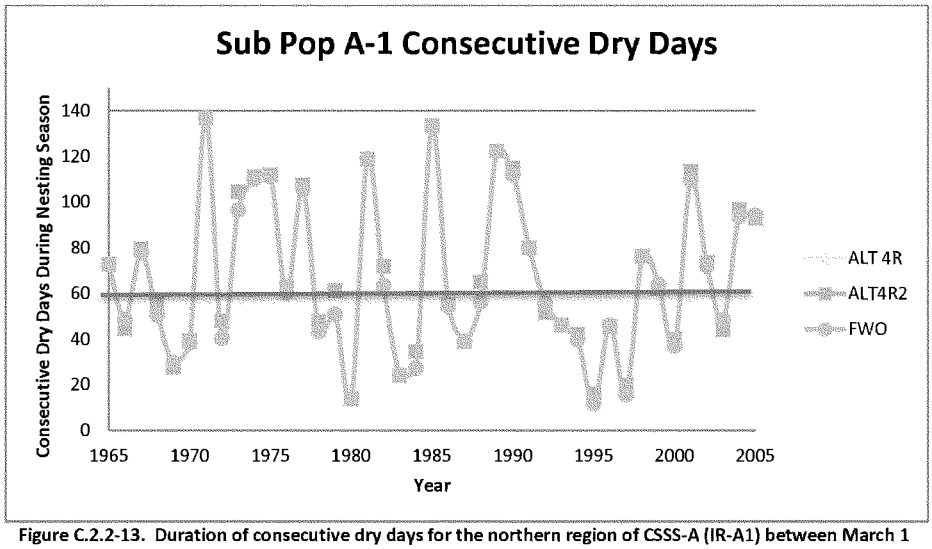


Figure C.2.2-13. Duration of consecutive dry days for the northern region of CSSS-A (IR-A1) between March 1 and July 15.

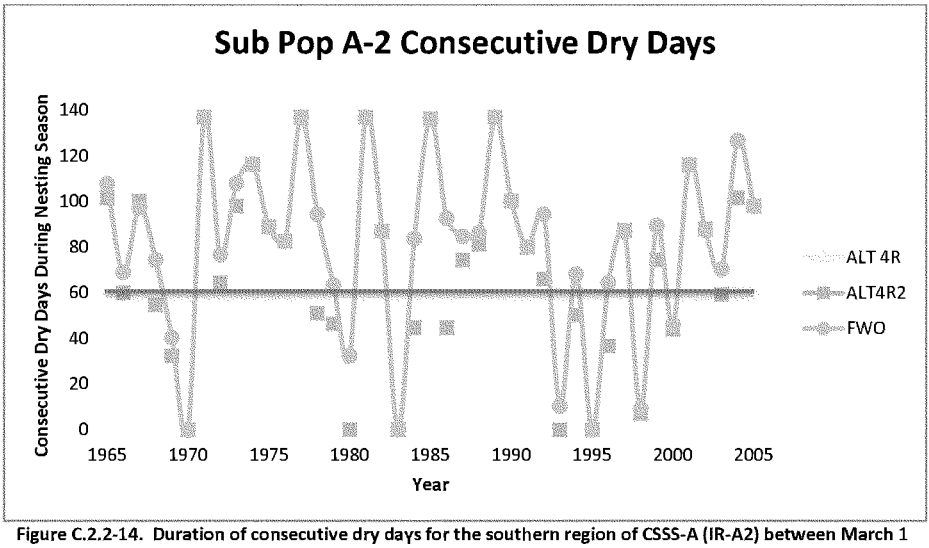


Figure C.2.2-14. Duration of consecutive dry days for the southern region of CSSS-A (IR-A2) between March 1 and July 15.

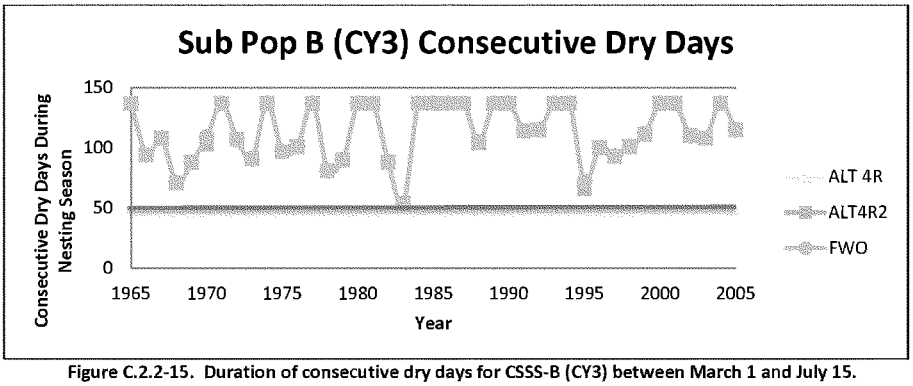


Figure C.2.2-15. Duration of consecutive dry days for CSSS-B (CY3) between March 1 and July 15.

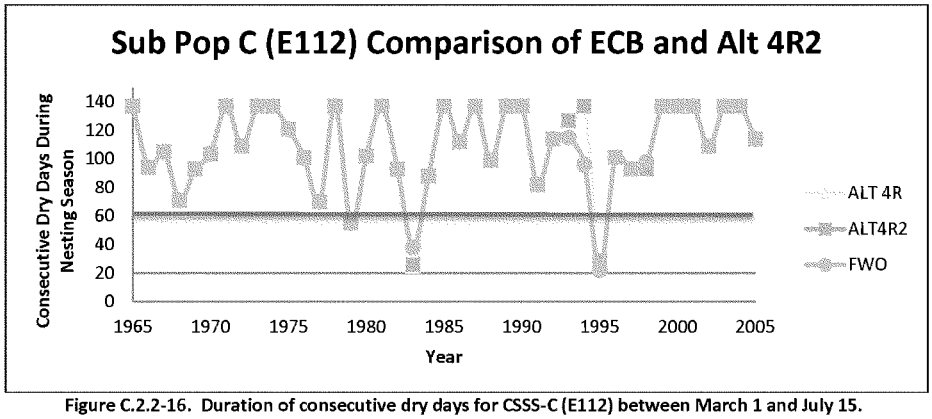


Figure C.2.2-16. Duration of consecutive dry days for CSSS-C (E112) between March 1 and July 15.

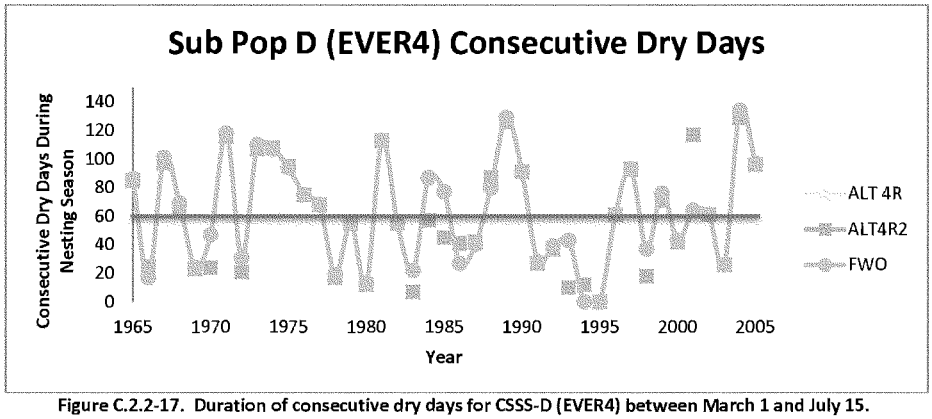


Figure C.2.2-17. Duration of consecutive dry days for CSSS-D (EVER4) between March 1 and July 15.

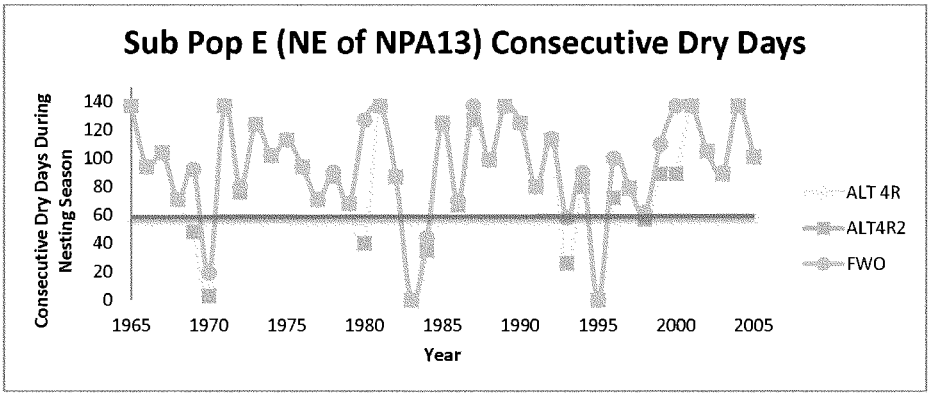


Figure C.2.2-18. Duration of consecutive dry days for CSSS-E (NE of NPA13) between March 1 and July 15.

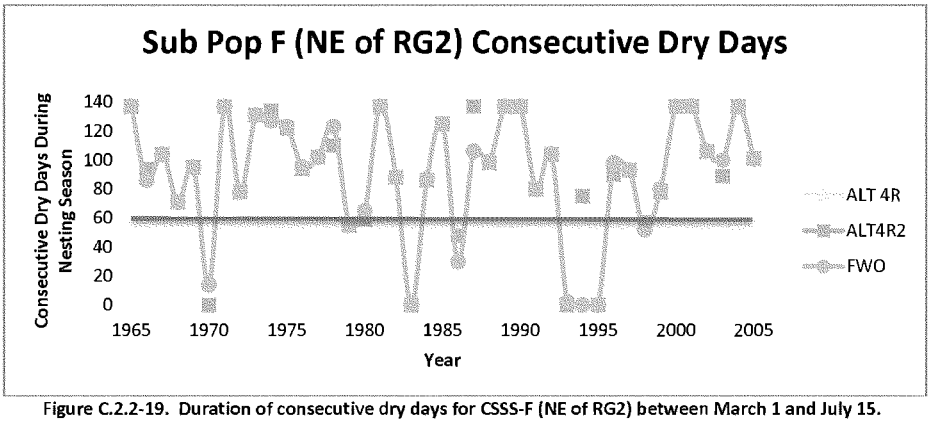


Figure C.2.2-19. Duration of consecutive dry days for CSSS-F (NE of RG2) between March 1 and July 15.

Further analysis of the PM-A data looked at the durations and timing of the total number of consecutive dry days during the nesting season for each year of the POR. Some of the consecutive day counts are close to 60, and may have been a day or a few days where the water level is just above the ground surface. In these cases, the cells were coded as yellow in that they may provide a suitable nesting season. Cells that are green met the 60 consecutive dry days and cells that are red did not meet the 60 consecutive dry days or even a total of 60 dry days during the nesting season. This analysis shows that for the northern CSSS sub population A (A-1), while there is still no difference between Alt 4R, Alt 4R2 and FWO, 1979 was a year in which there were 96 dry days for Alts 4R and 4R2 and 89 dry days for FWO that has the possibility of producing a successful nest (**Table C.2.2-3**). 1979 is also a year that is between years that did not reach 60 dry days during the nesting season, thus three consecutive years of nesting may not occur. 1984 is another year where Alts 4R and 4R2 do reach 60 dry days during the nesting season and in 2000, Alts 4R, 4R2 and FWO have a combined number of dry days greater than 60 during the nesting season. **Table C.2.2-3** shows that in the southern sub population A (A-2), while Alts 4R and 4R2 perform worse than FWO with more years and more consecutive years where there are less than 60

dry days during the nesting season, the breakdown of the days show that in 1979, there are 60 dry days during the nesting season as well as in 2000. **Table C.2.2-4** shows no difference between Alt 4R, Alt 4R2 and FWO in sub populations B and C, respectively. **Table C.2.2-5** shows that while Alts 4R and 4R2 perform slightly worse than FWO for CSSS sub population D, 1966 was a year in which there were 70 dry days for Alt 4R, 71 dry days for Alt 4R2 and only 48 dry days for FWO with Alts 4R and 4R2 having the possibility of producing a successful nest. A similar scenario was seen in 1986 where there were 67 dry days for Alt 4R, 68 dry days for Alt 4R2 and only 51 dry days for FWO. 1972, 1987, 1991, 1996 and 2000 were all years where Alts 4R, 4R2 and FWO have a combined number of dry days greater than 60 during the nesting season. **Table C.2.2-5** shows while that Alts 4R and 4R2 perform worse than FWO in the northern CSSS sub population E (E-1), there are a few years such as 1969, 1980 and 1984 where the alternatives do not meet the 60 consecutive dry day target, they do have at least 60 dry days during the nesting season and there are not three consecutive years where they do not reach 60 consecutive dry days during the nesting season. **Table C.2.2-6** shows while that Alts 4R and 4R2 perform worse than FWO in the southern CSSS sub population E (E-2), there are a few years such as 1972, 2000 and 2003 where the alternatives do not meet the 60 consecutive dry day target, but they do have at least 60 dry days during the nesting season. **Table C.2.2-6** shows that Alts 4R and 4R2 perform better than the FWO in CSSS sub population F and that there are a few years such as 1980 and 1986 where the alternatives do not meet the 60 consecutive dry day target, but they do have at least 60 dry days during the nesting season.

Table C.2.2-3. Total number of consecutive dry days during March 1 – July 15 for the northern CSSS sub population A-1 (left) and the southern CSSS subpopulation A-2 (right). Cells that are green have 60 or greater dry days during the nesting season. Cells that are yellow do not have 60 or more consecutive dry days during the nesting season, but do have a total of 60 or more dry days during the nesting season. Cells that are red do not have 60 dry days during the nesting season.

Sub Pop A-1	Alt 4R	Alt 4R2	FWO
Year	# consecutive dry days	# consecutive dry days	# consecutive dry days
1965	65, 1, 17	65, 1, 17	65, 1, 17
1966	64, 61	64, 61	64, 61
1967	104	104	69
1968	75	67	3, 3, 61
1969	3, 61, 11, 66	3, 61, 11, 66	3, 61, 11
1970	62	62	62
1971	117	117	117
1972	66, 66	66, 66	3, 3, 66
1973	117	117	12, 66
1974	112	112	112
1975	110	110	110
1976	61, 1	61, 1	61, 1
1977	110, 12	110, 12	104, 12
1978	3, 66	3, 66	66
1979	52, 3, 8, 29, 3	52, 3, 8, 29, 3	51, 2, 8, 8, 6, 15, 1
1980	66	66	66
1981	115	115	115
1982	67	67	67
1983	66	66	66
1984	6, 9, 1, 47, 25	6, 9, 1, 47, 25	6, 9, 1, 47, 25
1985	115, 1	115, 1	115
1986	1, 2, 1, 64	1, 2, 1, 64	1, 67
1987	66, 66	66, 66	3, 3, 66
1988	65, 1	65, 1	12, 65, 1
1989	123, 12	123, 12	123, 12
1990	112, 1	112, 1	104, 12
1991	66	66	66
1992	102	102	66
1993	75	75	75
1994	66	66	66
1995	65, 1	65, 1	1, 1, 65
1996	3, 72	3, 72	2, 1, 66
1997	66, 66	66, 66	12, 1
1998	3, 72	3, 72	3, 72
1999	67	67	67
2000	44, 58	44, 58	18, 43, 10
2001	113	113	113
2002	66	66	66
2003	61, 24	61, 24	61, 24
2004	121	121	12, 66
2005	66, 1	66, 1	66, 1

Sub Pop A-2	Alt 4R	Alt 4R2	FWO
Year	# consecutive days	# consecutive days	# consecutive days
1965	100	100	100
1966	61, 1, 3	61, 1, 3	71
1967	1, 100	1, 100	2, 70
1968	98	98	1, 72
1969	1, 94	1, 94	2, 70
1970	94	94	94
1971	117	117	117
1972	76	76	76
1973	116, 1	116, 1	116, 1
1974	117	117	117
1975	80	80	80
1976	81, 1	81, 1	81, 2
1977	117	117	117
1978	2, 94	2, 94	2, 72
1979	48, 1, 3, 3	48, 1, 3, 3	76, 6
1980	91	91	15, 11, 37, 5
1981	117	117	117
1982	67	67	67
1983	91	91	91
1984	77	77	67
1985	117	117	117
1986	94	94	72
1987	1, 93	1, 93	1, 93
1988	94	94	94
1989	117	117	117
1990	94, 1, 1	94, 1, 1	94, 1, 1
1991	91	91	91
1992	1, 93	1, 93	91
1993	91	91	91
1994	93, 1	93, 1	72, 1
1995	91	91	91
1996	2, 91, 1	2, 91, 1	91, 2
1997	13, 81	13, 81	13, 81
1998	91	91	91
1999	91	91	68
2000	11, 45, 9	11, 45, 9	11, 45, 10, 1
2001	116, 1	116, 1	116, 1
2002	91	91	91
2003	91, 25	91, 25	91
2004	116	116	107
2005	91	91	91

Table C.2.2-4. Total number of consecutive dry days during March 1 – July 15 for the CS5S sub population B (left) and sub population C (right). Cells that are green have 60 or greater dry days during the nesting season. Cells that are red do not have 60 dry days during the nesting season.

Sub Pop B	Alt 4R	Alt 4R2	FWO
Year	# consecutive days	# consecutive days	# consecutive days
1965	137	137	137
1966	94	94	94
1967	105	105	105
1968	71	71	71
1969	91	91	91
1970	111, 1	111, 1	111, 1
1971	137	137	137
1972	107	107	107
1973	121	121	121
1974	137	137	137
1975	97, 1, 4	97, 1, 4	137
1976	101	101	101
1977	137	137	137
1978	94	94	94
1979	137	137	137
1980	137	137	137
1981	137	137	137
1982	90	90	90
1983	59	59	59
1984	114	114	114
1985	137	137	137
1986	114, 17	114, 17	137
1987	137	137	137
1988	96, 2	96, 2	96, 2
1989	137	137	137
1990	137	137	137
1991	110	110	110
1992	116	116	116
1993	97, 14, 17	97, 14, 17	137
1994	137	137	137
1995	75	75	75
1996	104	104	104
1997	90	90	90
1998	104	104	104
1999	110	110	110
2000	137	137	137
2001	137	137	137
2002	104	104	104
2003	101, 4, 11	101, 4, 11	101, 4, 11
2004	137	137	137
2005	114, 1, 5	114, 1, 5	114, 1, 5

Sub Pop C	Alt 4R	Alt 4R2	FWO
Year	# consecutive days	# consecutive days	# consecutive days
1965	137	137	137
1966	94	94	94
1967	105	105	105
1968	71	71	71
1969	91	91	91
1970	91	91	91, 1, 2
1971	137	137	137
1972	104, 2	104, 2	104
1973	121, 1, 5	121, 1, 5	121, 1, 5
1974	125, 1	125, 1	125
1975	116	116	116
1976	98, 3	98, 3	98, 3
1977	91, 11, 26	91, 11, 26	91, 11, 27
1978	1, 1, 125	1, 1, 125	1, 1, 125
1979	66, 56	66, 56	66, 57
1980	1, 135	1, 135	135
1981	137	137	137
1982	90, 14	90, 14	90, 14
1983	59, 1, 2	59, 1, 2	59, 1, 2
1984	44, 77	44, 77	44, 77
1985	124, 4, 4	124, 4, 4	124, 4
1986	112, 1, 1, 4	112, 1, 1, 4	112, 4
1987	137	137	137
1988	96	96	96
1989	137	137	137
1990	137	137	137, 13
1991	87	87	87
1992	116	116	116
1993	92, 14, 2, 1	92, 1, 17, 7	92, 1, 17, 7
1994	1, 93, 43	1, 93, 1, 11	1, 93, 11, 12
1995	1, 74	1, 74	1, 74, 28
1996	96, 4	96, 4	96, 4
1997	91, 10	91, 10	91, 10
1998	91	91	91
1999	111, 1, 3	111, 1, 3	111, 1, 4
2000	137	137	137
2001	137	137	137
2002	104	104	104
2003	100, 1, 17	100, 1, 18	100, 1, 2, 16
2004	137	137	137
2005	101, 8	101, 8	101, 8

Table C.2.2-5. Total number of consecutive dry days during March 1 – July 15 for the CSSS sub population D (left) and southern sub population E (E-1, right). Cells that are green have 60 or greater dry days during the nesting season. Cells that are yellow do not have 60 or more consecutive dry days during the nesting season, but do have a total of 60 or more dry days during the nesting season. Cells that are red do not have 60 dry days during the nesting season.

Sub Pop D	AR 4R	AR 4R2	FWO
Year	# consecutive days	# consecutive days	# consecutive days
1965	111, 5, 14	111, 5, 14	111, 5, 14
1966	3, 24, 27, 16	3, 35, 27, 16	3, 35, 16
1967	104	104	104
1968	69	69	69
1969	76	76, 1	76, 1
1970	61	61	61
1971	114, 2, 2, 4	114, 2, 2, 4	114, 2, 4
1972	31, 5, 12, 16	31, 5, 12, 16	31, 5, 12, 17
1973	114	114	114
1974	110	110	110
1975	90, 21	90, 10, 10	90, 7, 7, 10
1976	75, 1, 2	75, 1, 2	75, 1, 1
1977	66, 1, 1, 6	66, 1, 1, 6	66, 1, 1, 6
1978	94	94	94, 1
1979	92	92	92
1980	15, 30, 41, 4	15, 29, 40, 4	1, 137
1981	119	119	119
1982	87	87	87
1983	96	96	96
1984	32, 5, 35, 8, 4	32, 5, 35, 8, 2, 1	44, 35, 4, 7
1985	126	126	126
1986	30, 49	30, 49	30, 30
1987	5, 4, 48, 51	5, 6, 49, 51	6, 13, 47, 47
1988	94	94	94
1989	126, 7	126, 7	126
1990	87, 10	87, 8, 10	87, 4, 10
1991	2, 45, 28	2, 45, 29	2, 44, 28
1992	90, 25	90, 25	90, 25
1993	96	96	96, 15
1994	1, 52, 3, 3	1, 52, 3, 3	1, 52, 3, 3
1995	96	96	96
1996	45, 23	45, 23	2, 47, 23
1997	93	93	93
1998	15, 77, 2	15, 77, 2	15, 77, 2
1999	84	84	2, 154
2000	43, 34, 1	43, 54, 1	100, 2
2001	101, 19, 4	101, 19, 4	101, 19, 4
2002	99	99	99
2003	96, 5, 1	96, 5, 1	96, 10, 1
2004	111	111	111
2005	101	101	101

Sub Pop E-1	AR 4R	AR 4R2	FWO
Year	# consecutive days	# consecutive days	# consecutive days
1965	107	107	107
1966	94	94	94
1967	104	104	104
1968	71	71	71
1969	14, 48, 11, 1	15, 48, 11, 1	60
1970	61	61	61
1971	117	117	117
1972	31, 5	31, 5	31, 5
1973	124	124	124
1974	102	102	102
1975	111, 1	111, 1	111, 1
1976	94	94	94
1977	71, 14, 1, 1, 6	71, 14, 1, 1, 6	71, 14, 1, 1, 6
1978	97	97	90
1979	88, 7	88, 7	88, 14, 1, 1, 1
1980	15, 30, 41, 4	15, 29, 40, 4	1, 137
1981	119	119	119
1982	87	87	87
1983	96	96	96
1984	32, 5, 35, 8, 4	32, 5, 35, 8, 2, 1	44, 35, 4, 7
1985	126	126	126
1986	30, 49	30, 49	30, 30
1987	5, 127	5, 127	127
1988	94	94	94
1989	127	127	127
1990	125, 1, 1	125, 1, 1	125, 1, 1
1991	90	90	90
1992	115	115	114
1993	96	96	96, 15
1994	1, 52, 3, 3	1, 52, 3, 3	1, 52, 3, 3
1995	96	96	96
1996	1, 71, 10	2, 71, 10	2, 80
1997	93	93	93, 1
1998	92	92	92
1999	90	90	155
2000	44, 89	44, 89	133
2001	127	127	127
2002	115	115	115
2003	96	96, 1	96, 1, 1
2004	117	117	117
2005	101	101	101

Table C.2.2-6. Total number of consecutive dry days during March 1 – July 15 for the southern CSSS sub population E (E-2, left) and sub population F (right). Cells that are green have 60 or greater dry days during the nesting season. Cells that are yellow do not have 60 or more consecutive dry days during the nesting season, but do have a total of 60 or more dry days during the nesting season. Cells that are red do not have 60 dry days during the nesting season.

Sub Pop E-2	Alt 4A	Alt 4B2	FWO
Year	# consecutive days	# consecutive days	# consecutive days
1965	137	137	137
1966	2, 70	2, 70	84
1967	104	104	104
1968	70	70	71
1969	3, 3, 68	3, 3, 68	3, 3, 68
1970	70	70	70
1971	137	137	137
1972	24, 1, 36	24, 1, 36	35, 1, 40
1973	1, 1, 72	1, 1, 72	1, 2, 72
1974	104	104	104
1975	80	80	80
1976	88	88	88
1977	71, 15, 1, 1, 1	71, 15, 1, 1, 1	71, 15, 1, 1, 1
1978	71	71	74
1979	92	92	92, 1
1980	1, 38	38	14, 41, 1, 40, 5
1981	2, 71	1, 71	71, 1
1982	87	87	87
1983	1	1	1
1984	12, 58	2, 2, 58	12, 58
1985	104	104	104
1986	25, 71	25, 71	103
1987	3, 99	3, 99	3, 103
1988	96	96	96
1989	137	137	137
1990	117	117	117
1991	80	80	80
1992	21, 73	21, 73	97
1993	2, 2	2, 2	64, 1, 1
1994	28, 2, 28	28, 2, 28	28
1995	2	2	2
1996	2, 94, 94	2, 94, 94	3, 77, 1
1997	70	70	70
1998	88	88	88
1999	92	92	92
2000	16, 42	16, 43	43, 46, 1, 2
2001	117	117	117
2002	91, 4	91, 4	91, 5
2003	16, 8, 21, 19	16, 8, 21, 19	28, 33, 19
2004	125	125	125
2005	94	94	94

Sub Pop F	Alt 4A	Alt 4B2	FWO
Year	# consecutive days	# consecutive days	# consecutive days
1965	137	137	137
1966	84	84	84
1967	104	104	104
1968	71	71	71
1969	65	65	65
1970	70	70	70
1971	137	137	137
1972	36	36	36
1973	111	111	111
1974	104, 2	104, 2	107, 1, 1
1975	122	122	122
1976	84	84	84, 1
1977	94, 1, 23	94, 23	94, 24
1978	3, 110	3, 110	111
1979	92	92	92
1980	10, 57, 2	9, 59	1, 21, 2, 45
1981	71	71	71
1982	86	86	86
1983	1	1	1
1984	86	86	87
1985	103, 1	103, 1	103, 1
1986	25, 48	25, 48	73, 1, 1
1987	101	101	30, 104
1988	96	96	96
1989	137	137	137
1990	117	117	117
1991	80	80	80
1992	104	104	104
1993	2	2	2
1994	28, 2, 2, 23	28, 28	28
1995	2	2	2
1996	86	86	86
1997	92	92	92, 1
1998	88	88	88
1999	77, 6, 5	77, 6, 5	83, 5, 5
2000	117	117	117
2001	117	117	117
2002	104	104	104
2003	88	88	88
2004	117	117	117
2005	103	103	103

ET-1 (NP-205, CSSS-A): Strive to reach a water level of less than or equal to 7.0 feet, NGVD at NP-205 by December 31 for nesting season water levels to reach 6.0 feet, NGVD by mid-March.

As illustrated by **Figure C.2.2-20** ET-1 would have been achieved in 97 percent of years (39 of 40 years) in Alternatives 4R and 4R2 and the FWO.

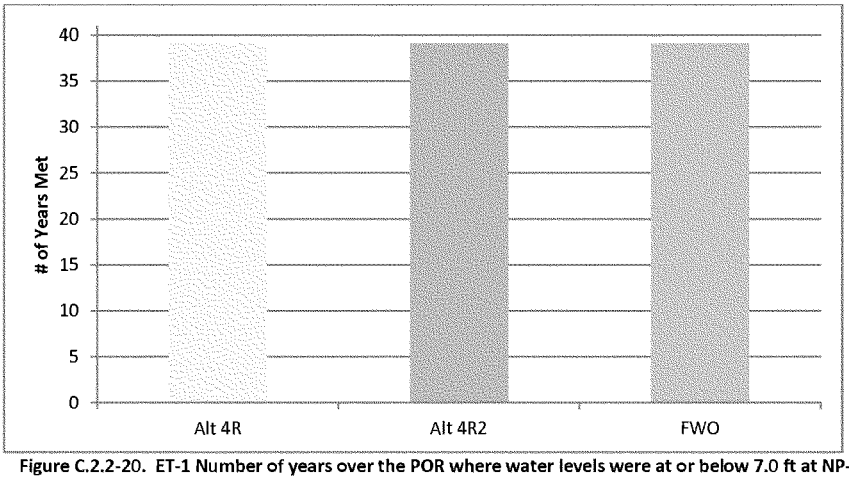


Figure C.2.2-20. ET-1 Number of years over the POR where water levels were at or below 7.0 ft at NP-205 by December 31 for nesting season water levels to reach 6.0 feet by mid-March for the four alternatives and the No Action Alternative (FWO).

ET-2 (CSSS): Strive to maintain a hydroperiod between 90 and 210 days (three to seven months) per year throughout sparrow habitat to maintain marl prairie vegetation.

To maintain suitable habitat for CSSS, the annual hydroperiod (i.e. time above ground surface during wet season) should be between 90 and 210 days. Sparrows prefer to nest in short-stature clumped grasses such as *Muhlenbergia*, *Schizachryium*, and *Schoenus*. Habitat can tolerate infrequent years of up to 240 days and below 90 days. In order to compare alternatives for hydroperiod throughout CSSS habitat, ETs were used. RSM-GL results for each CSSS subpopulation are depicted in **Table C.2.2-7** and **Figure C.2.2-21** through **Figure C.2.2-29**. **Table C.2.2-7** and **Figure C.2.2-21** compares Alternatives 4R and 4R2 to the FWO to maintain a hydroperiod between 90 and 210 days (three to seven months) per year throughout sparrow habitat to maintain marl prairie vegetation. Alternatives 4R and 4R2 performed better than the FWO in the Northern subpopulation A (10 years met compared to 6 in FWO; **Figure C.2.2-22**) and show a minor beneficial effect. Alternatives 4R and 4R2 perform slightly worse than the FWO for southern subpopulation A (8 years met compared to 9 in FWO; **Figure C.2.2-23**) and subpopulation B (24 years met compared to 25 in FWO; **Figure C.2.2-24**) and show a minor adverse effect. Alternatives 4R and 4R2 perform worse than the FWO for subpopulation C (16 years met for 4R and 15 years met for 4R2 compared to 19 for FWO; **Figure C.2.2-25**), subpopulation D (12 years met for 4R and 13 years met for 4R2 compared to 16 years for FWO; **Figure C.2.2-26**), northern subpopulation E (17 years met for 4R and 18 years met for 4R2 compared to 24 for FWO; **Figure C.2.2-27**), southern subpopulation E (10 years compared to 12 years for FWO; **Figure C.2.2-28**) and subpopulation F (15 years met for 4R and 14 years met for 4R2 compared to 18 for FWO; **Figure C.2.2-29**) and show a major

adverse effect. **Figure C.2.2-30** through **Figure C.2.2-37** show the hydroperiod in each sub population and the target number of days within the hydroperiod. In looking at the amount of time the hydroperiod is in the target range of 90 – 210 days below 7.0 ft over the entire POR, **Figure C.2.2-30** shows that Alternatives 4R and 4R2 spend more time within the target range over the POR than FWO for sub population A-1, the northern sub population A population. In the southern portion of sub population A (A-2) FWO spends slightly more time within the target range than Alternatives 4R and 4 R2 (**Figure C.2.2-31**). In sub populations B and D there is no significant difference between Alternatives 4R, 4R2 and FWO with the amount of time over the POR that is spent within the target range (**Figure C.2.2-32** and **Figure C.2.2-34**). In sub populations C and E-2 (southern sub population E) Alternatives 4R and 4R2 had slightly less time in the target ranges than the FWO during the POR (**Figure C.2.2-33** and **Figure C.2.2-36**). Sub populations E-2 (southern sub population E) and F show the greatest difference between Alternatives 4R and 4R2 and FWO with Alts 4R and 4R2 spending a greater amount of the POR outside of the target range (**Figure C.2.2-35** and **Figure C.2.2-37**).

Table C.2.2-7. Number of years out of the period of record that the hydroperiod was between 90 and 210 days (three to seven months) each year throughout sparrow habitat in order to maintain marl prairie vegetation.

CSSS Subpopulation	Alt 4R	Alt 4R2	FWO
Northern A (A-1)	10	10	6
Southern A (A-2)	8	8	9
B	24	24	25
C	16	15	19
D	12	13	16
Northern E (E-1)	17	18	24
Southern E (E-2)	10	10	12
F	15	14	18

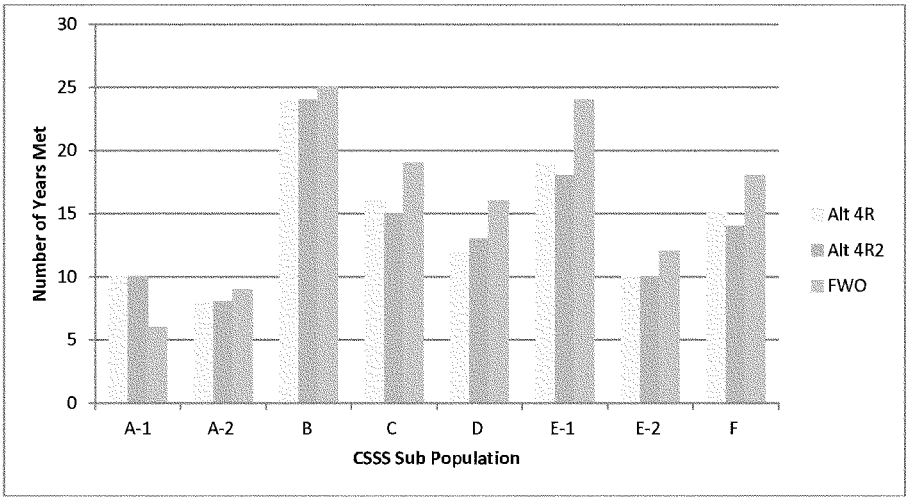


Figure C.2.2-21. Number of years out of the period of record that the hydroperiod was between 90 and 210 days (three to seven months) each year throughout sparrow habitat in order to maintain marl prairie vegetation.

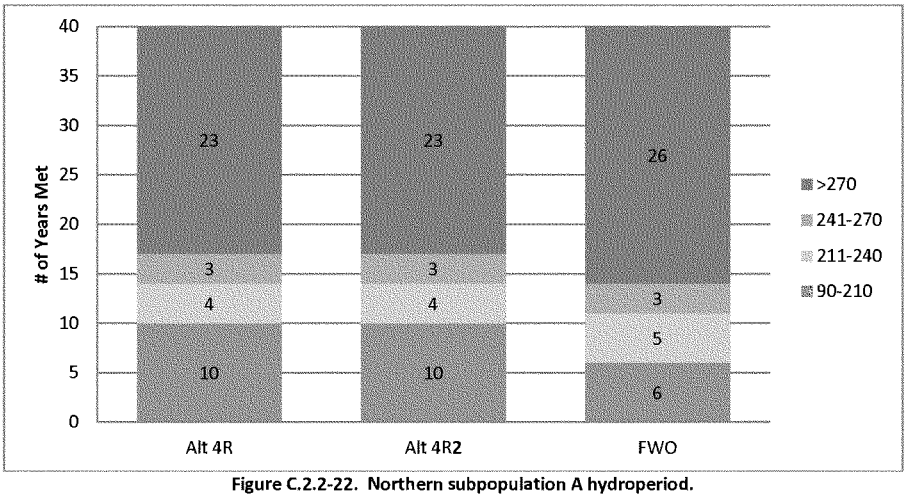


Figure C.2.2-22. Northern subpopulation A hydroperiod.

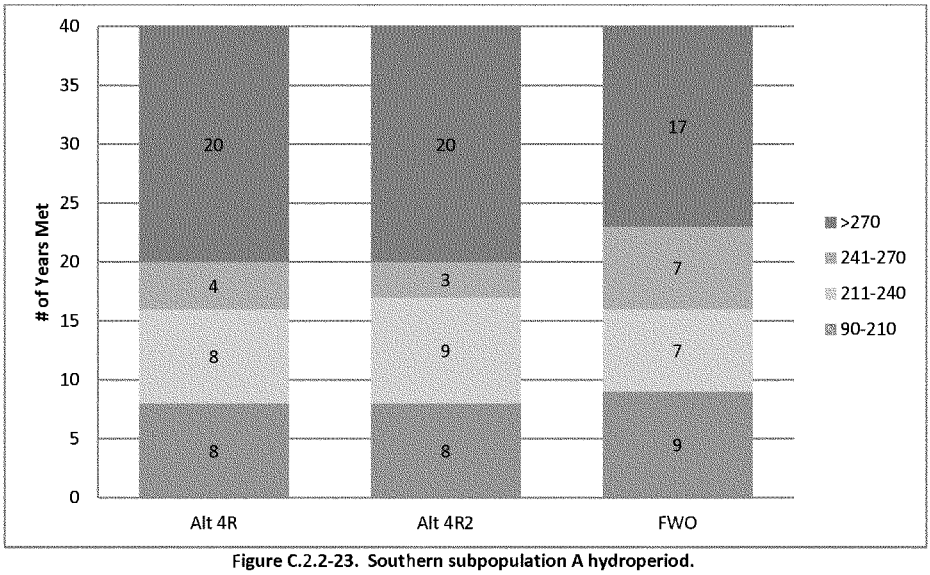


Figure C.2.2-23. Southern subpopulation A hydroperiod.

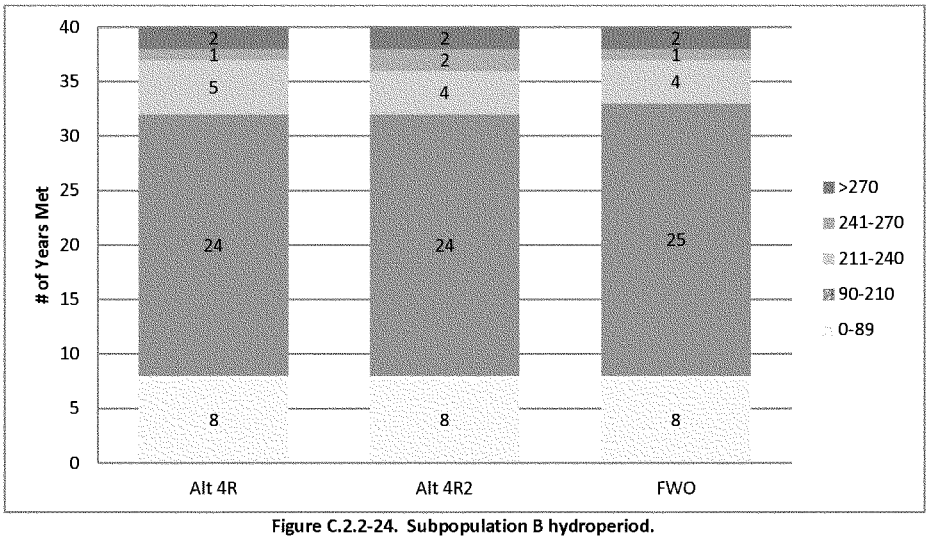


Figure C.2.2-24. Subpopulation B hydroperiod.

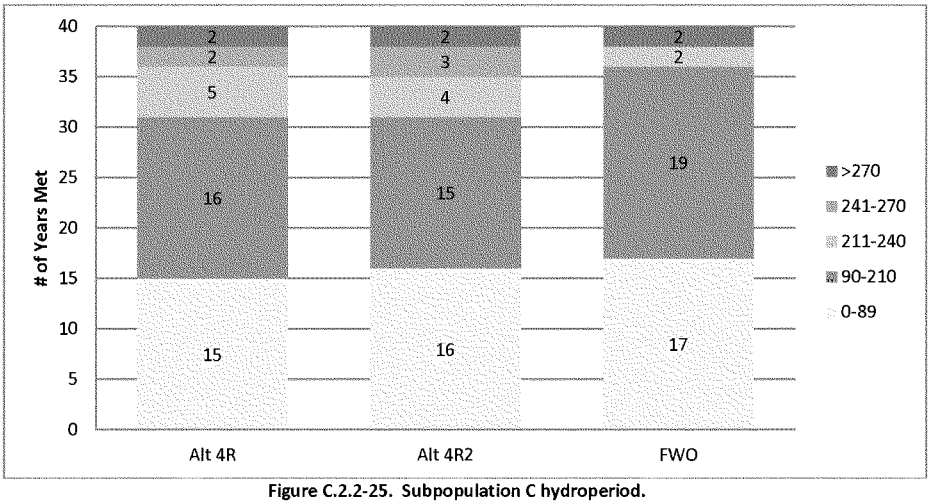


Figure C.2.2-25. Subpopulation C hydroperiod.

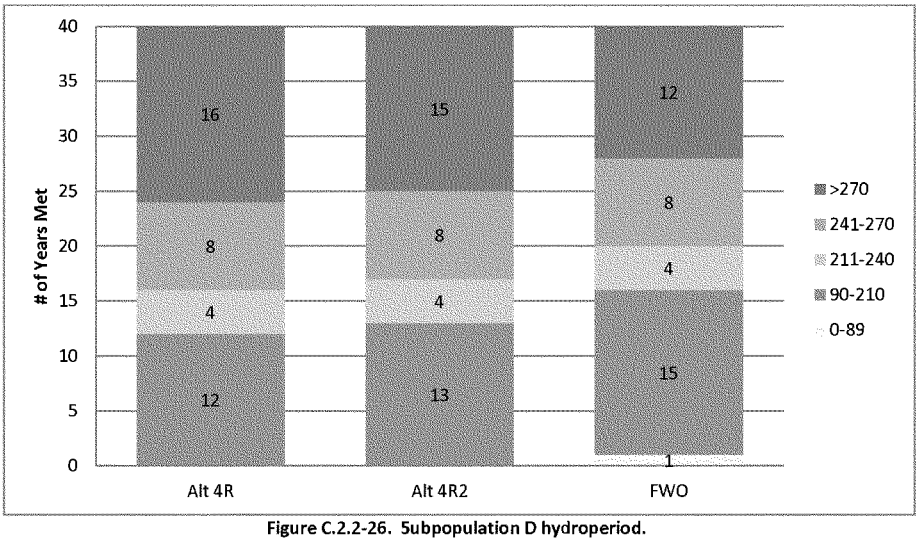


Figure C.2.2-26. Subpopulation D hydroperiod.

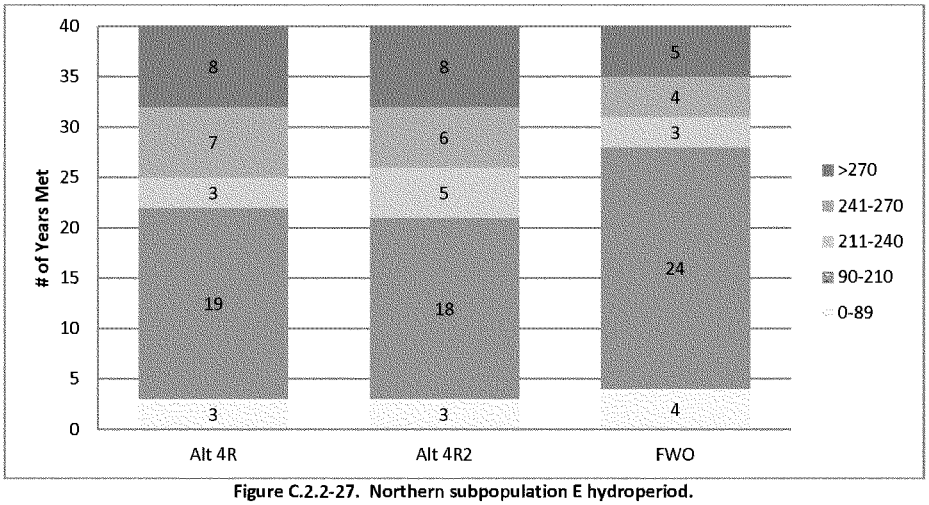


Figure C.2.2-27. Northern subpopulation E hydroperiod.

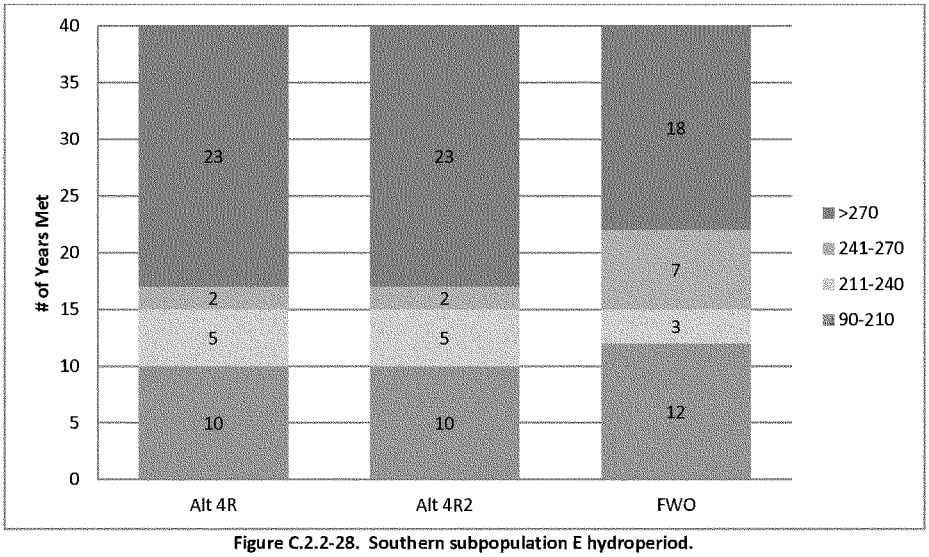


Figure C.2.2-28. Southern subpopulation E hydroperiod.

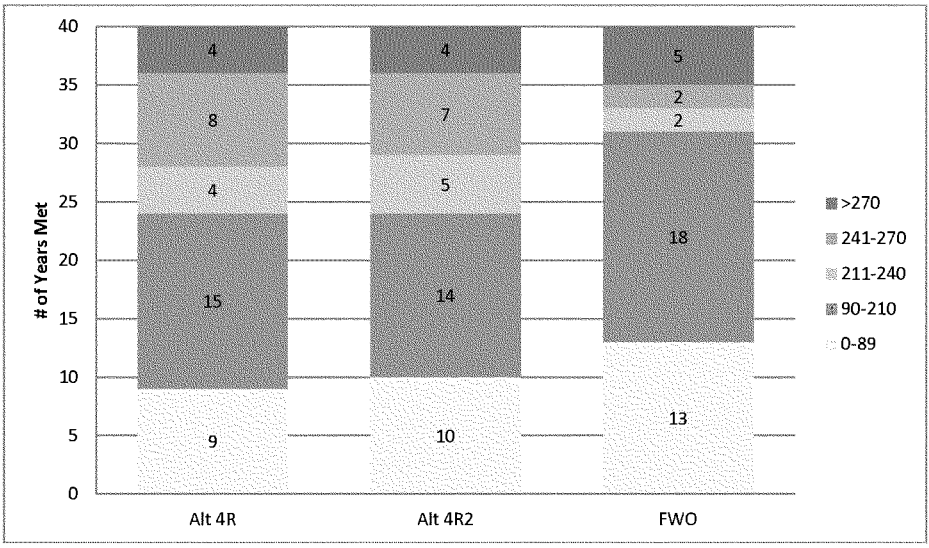


Figure C.2.2-29. Subpopulation F hydroperiod.

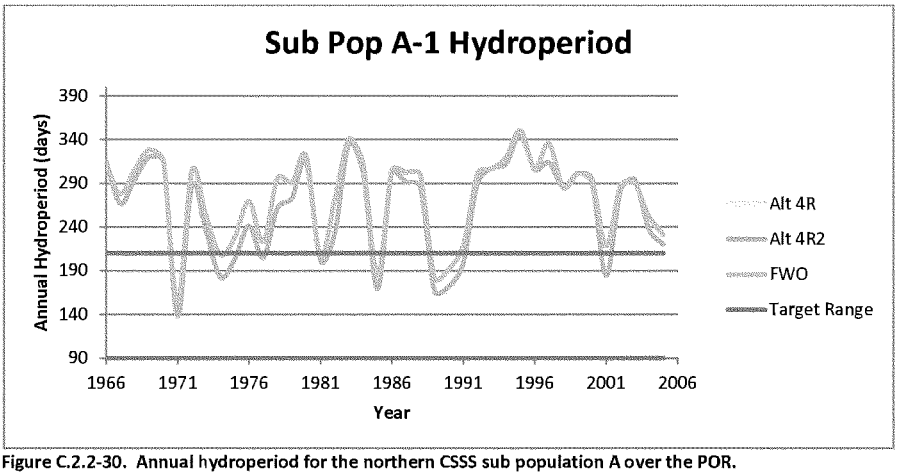


Figure C.2.2-30. Annual hydroperiod for the northern CSSS sub population A over the POR.

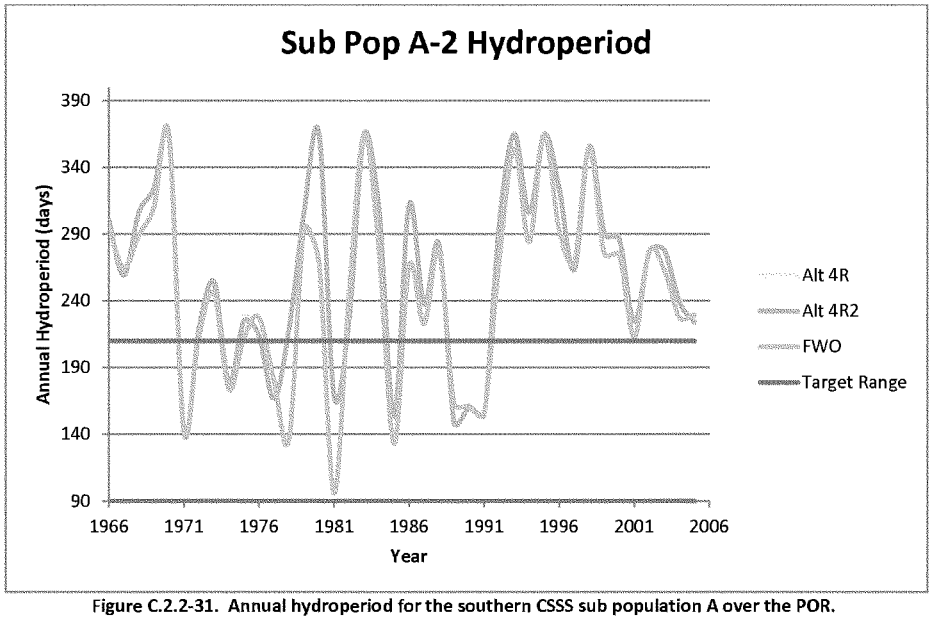


Figure C.2.2-31. Annual hydroperiod for the southern CSSS sub population A over the POR.

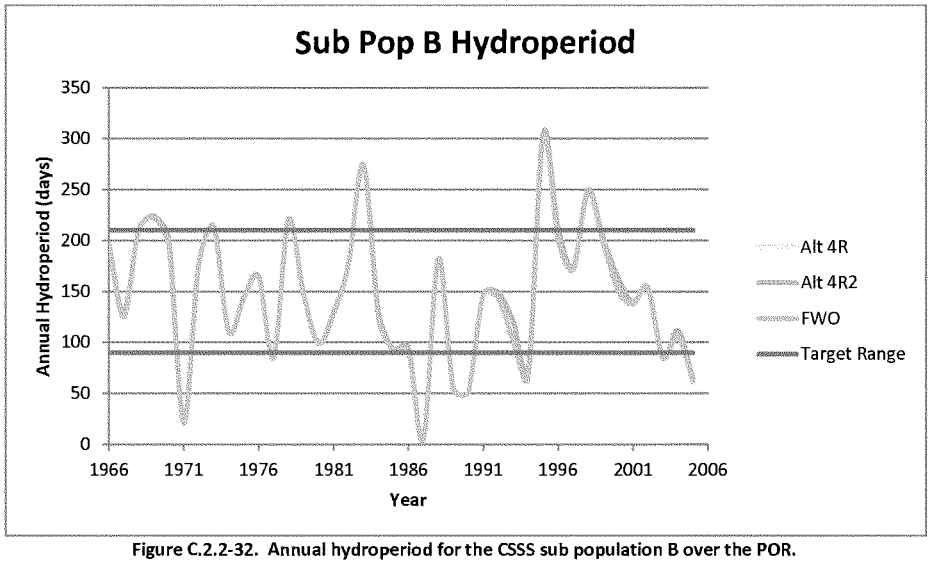


Figure C.2.2-32. Annual hydroperiod for the CSSS sub population B over the POR.

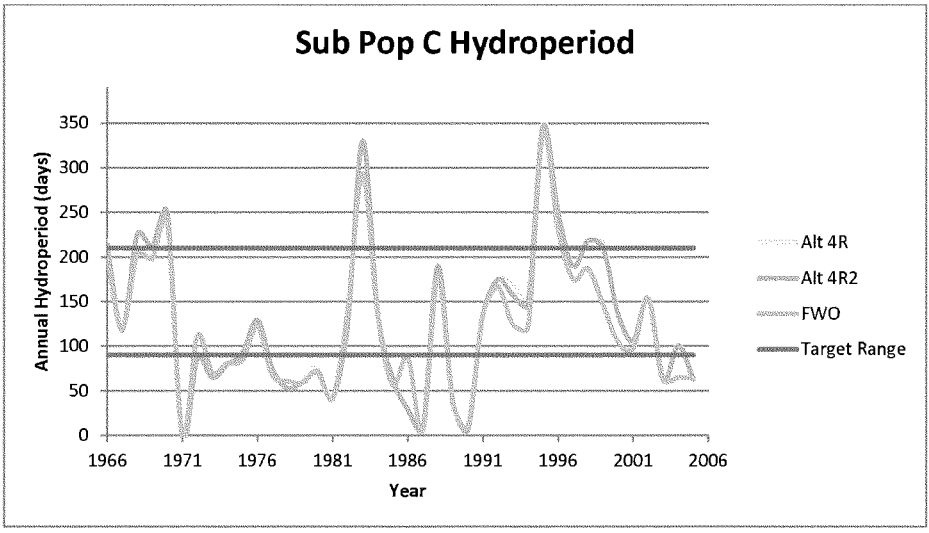


Figure C.2.2-33. Annual hydroperiod for the CSSS sub population C over the POR.

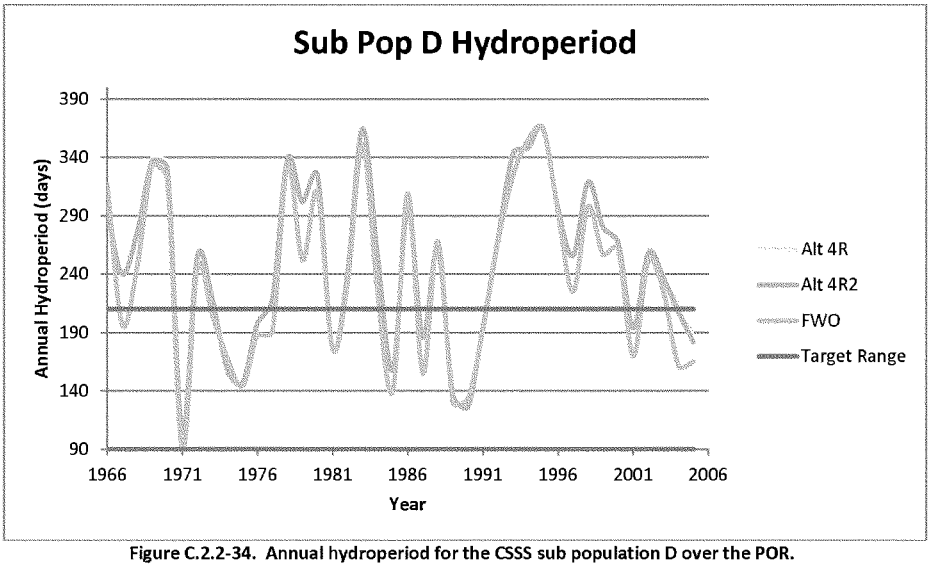


Figure C.2.2-34. Annual hydroperiod for the CSSS sub population D over the POR.

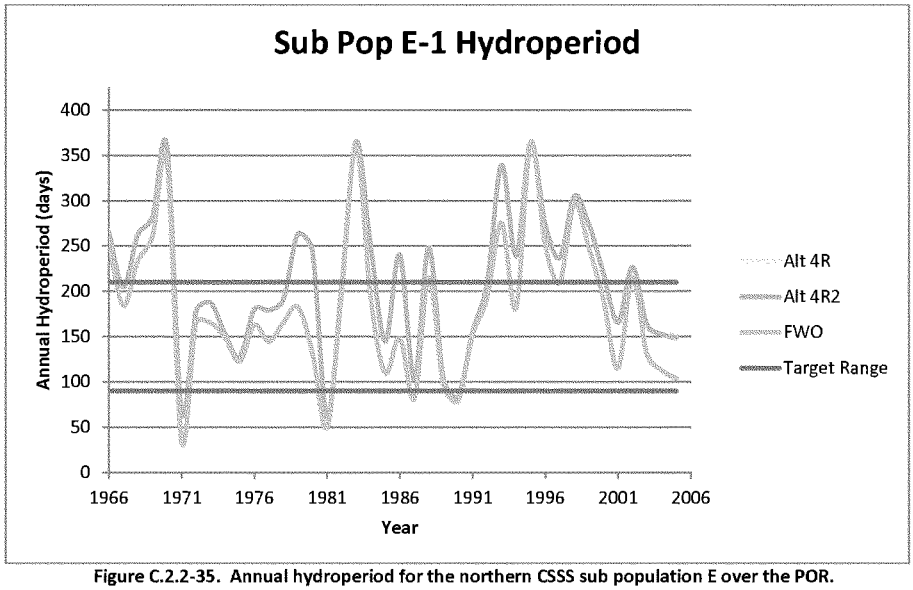


Figure C.2.2-35. Annual hydroperiod for the northern CSSS sub population E over the POR.

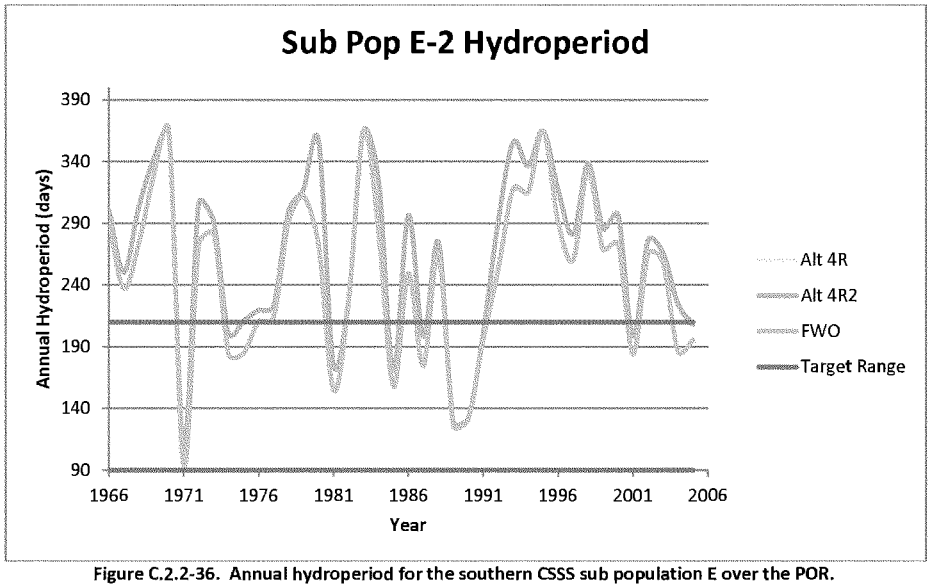


Figure C.2.2-36. Annual hydroperiod for the southern CSSS sub population E over the POR.

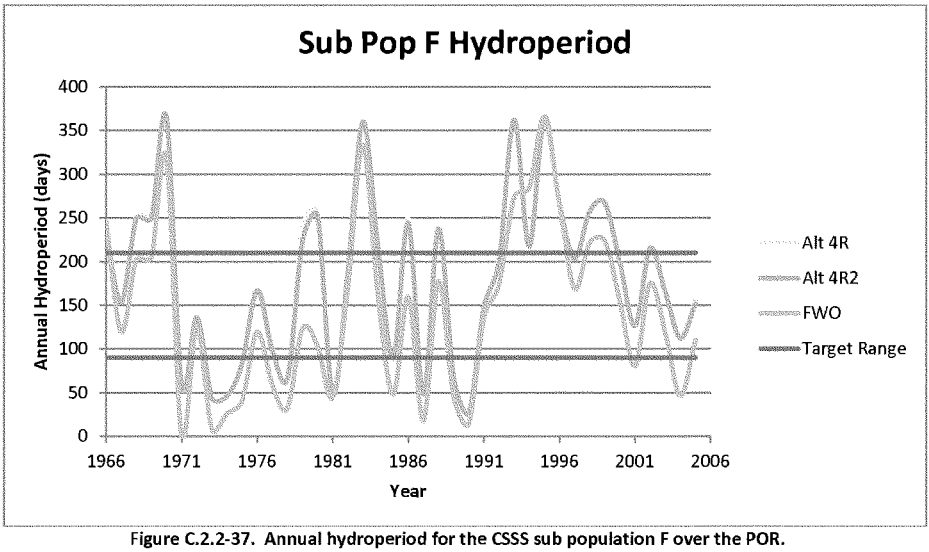


Figure C.2.2-37. Annual hydroperiod for the CSSS sub population F over the POR.

Implementation of Alts 4R and 4R2 has the potential to have a major adverse effect and significant and unavoidable effect on hydroperiods within the marl prairies adjacent to SRS. Modeling indicates an increase in hydroperiod within CSSS-E and southern portions of CSSS-A. However, hydroperiods within northern CSSS-A are slightly reduced as compared with FWO, providing slightly better, but overall, too wet conditions for marl prairie habitat and nesting CSSS. Minor habitat improvements were seen in CSSS-F.

C.2.2.4.3 Wood Stork

Wood storks rely upon short hydroperiod wetlands (i.e. marl prairies) for pre-breeding foraging. Short hydroperiod wetlands would help increase body condition and would allow for wood storks and other wading birds to initiate nesting earlier than they do now (November versus February). This will improve nesting success by reducing potential for nest abandonment, increasing juvenile survival by ensuring prey are available within CFA and allowing juveniles to fledge prior to end of dry season/start of wet season when food availability decreases around nests.

Several models of wading birds were used to assess potential affects to wading birds within the Greater Everglades as a result of implementation of CEPP Alt 4R including: 1) Wood Stork Foraging Probability Index model (SFNRC 2013a) 2) wading bird species distribution (Beerens 2013); and 3) wading bird nesting success (Beerens et al. 2014). ERTP PMs are captured within the Beerens models.

A Wood Stork Foraging Probability Index model (ENP 2013) was used to assess potential affects to wading birds within the Greater Everglades as a result of CEPP implementation. An analysis of wood stork foraging potential was performed to predict improvements to foraging habitat with CEPP implementation (ENP 2013). The Wood Stork Foraging Probability Index (STORKI v. 1.0) was developed to provide rapid simulations of wood stork foraging conditions in response to modeled CERP scenarios (LoGalbo et al. 2012).

Figure C.2.2-38 and **Figure C.2.2-39** indicate that Alt 4R2 provides the greatest benefit within northeastern WCA 3, areas adjacent to the Miami Canal, and throughout ENP relative to the existing conditions. Wood stork foraging suitability notably improves with Alt 4R2 in northern WCA 3A (CEPP zones 3A-MC and 3A NE) and within southern ENP, providing a moderate beneficial effect. Less substantial benefits occur within NW WCA 3A (CEPP zone 3A-NW), and southeast Everglades National Park (CEPP zone ENP-S) relative to the FWO. Benefits generally result from the increased water deliveries to these regions which result in more suitable water depths for wood stork foraging as compared to the FWO. Substantial declines in stork foraging suitability occur within northern Everglades National Park (CEPP Zone ENP-N) with Alt 4R and Alt4R2 relative to future conditions without CEPP, providing moderate adverse effects. The effects of increasing flow deliveries to Everglades National Park through the Blue Shanty Flow-way results in downstream water depths in ENP-N substantially less suitable for wood stork foraging. Less substantial negative impacts to wood stork foraging also occur in central and southern WCA 3A central (CEPP Zones 3A-C and 3A-S) with Alt 4R and Alt4R2 as compared to the FWO.

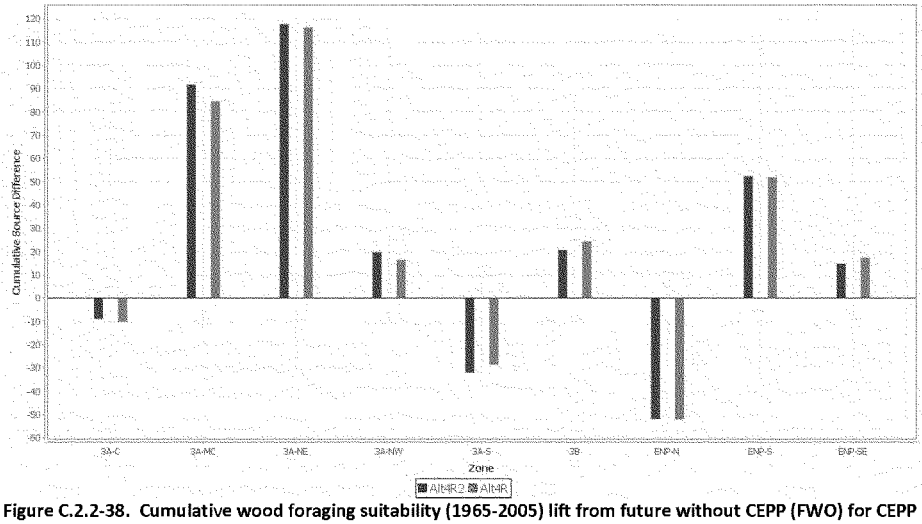


Figure C.2.2-38. Cumulative wood foraging suitability (1965-2005) lift from future without CEPP (FWO) for CEPP recommended plan (ALT4R2) and CEPP alternative (Alt4R) within each CEPP zone. A maximum score of 1327 is possible if FWO has a suitability score of 0.0 every week and the alternative has a suitability score of 1.0 every week of the 41 year hydrologic model runs.

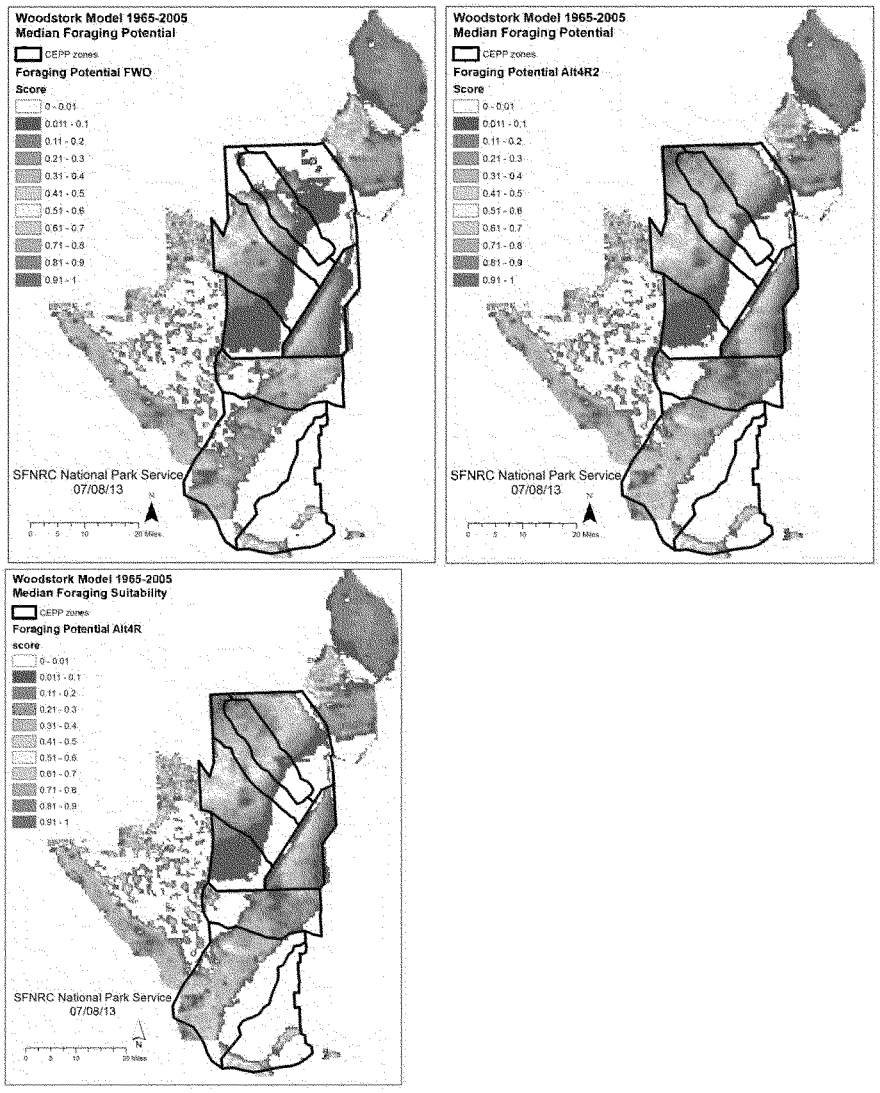


Figure C.2.2-39. Median wood stork foraging potential suitability scores for 1965-2005. Scores vary from 0.0 (not suitable) to 1.0 (optimal foraging). Existing conditions is shown in the left panel and Alt 4R2 in the right panel (SFNRC 2013a).

Wood stork species distribution was modeled by Beerens (2013) in support of the RECOVER Greater Everglades ecological evaluation. The objectives of the spatial foraging conditions model (SFC) are to determine the average hydrological and spatial characteristics of a cell that predict the species-specific

frequency of cell use over the study period. Wood storks generally showed increased numbers in northern WCA 3A, WCA 3B, and southern ENP under Alt 4R and Alt 4R2 compared to the FWO (**Figure C.2.2-40** and **Figure C.2.2-41**).

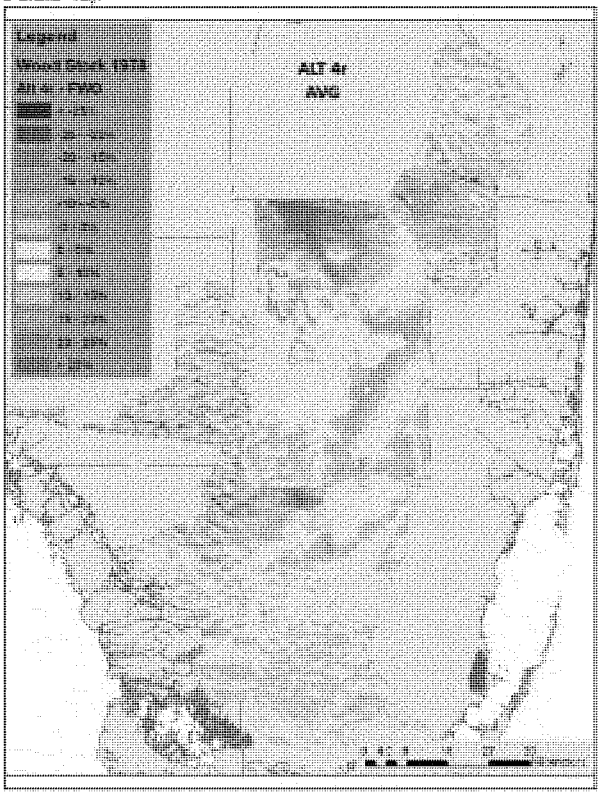


Figure C.2.2-40. CEPP RSM WADEM Spatial Foraging Conditions Model Output for Wood Stork for Alt 4R as compared with FWO for 1978, an average year. (Beerens 2013).

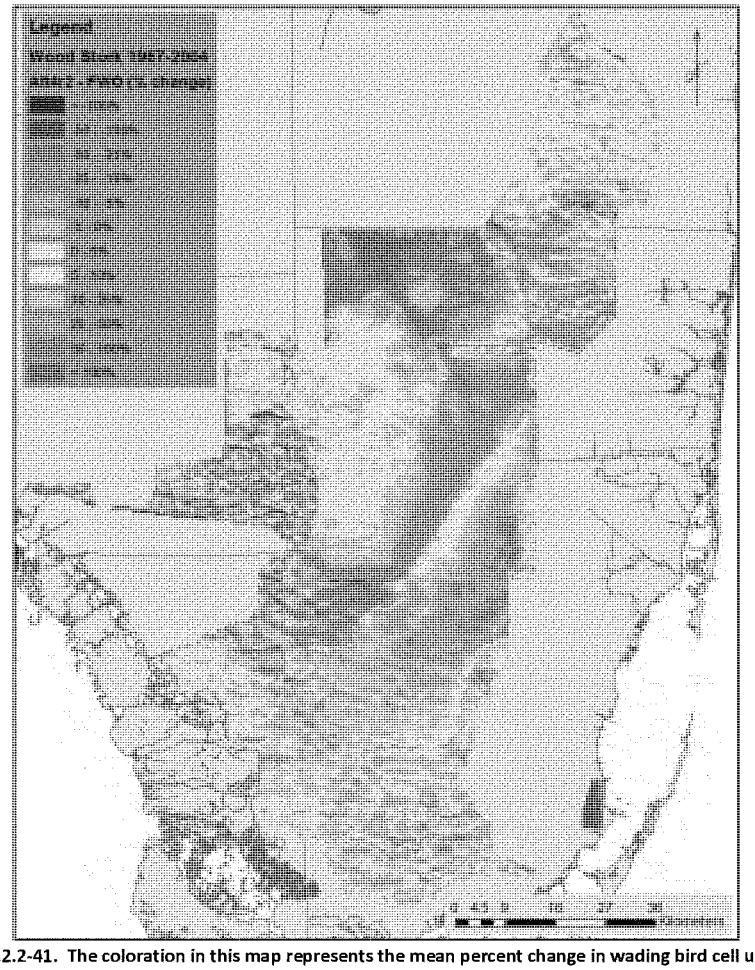


Figure C.2.2-41. The coloration in this map represents the mean percent change in wading bird cell use (Jan – May, 1967-2004) for Alt4R2 relative to Future Without (FWO).

Historically, the short hydroperiod wetlands within ENP have been important for wood stork foraging during the pre-breeding season with the storks shifting to longer hydroperiod wetlands as the dry season progresses. Hydrological patterns that produce a maximum number of patches with high prey availability (i.e. high water levels at the end of the wet season and low water levels at the end of the dry season) are necessary for high reproductive outputs (Gawlik 2002; Gawlik et al. 2004). Depending upon the elevation and microtopography throughout the WCAs and ENP, implementation of CEPP will produce a variety of wetland habitats that would support prey densities conducive to successful wading bird foraging and nesting.

Water depth and recession rate are the two most important hydrological variables for wood storks (Gawlik et al. 2004) and wading birds. In their analysis of habitat suitability, Gawlik et al. (2004) identified feeding sites where the weekly average water depths from November to April (pre-breeding and breeding season) were between 0.0 and 0.5 feet as the most suitable. Suitability drops to 0.0 when water depths are -0.3 feet below marsh surface or greater than 0.8 feet. Wood storks and other wading birds require recession condense their prey items into shallow pools for more effective foraging. It is recognized that areas of suitable foraging habitat will vary both within and between years due to microtopography, antecedent conditions, hydrological and meteorological conditions, and water management actions. It is anticipated that these provisions within CEPP will help to improve foraging conditions within WCA 3A and provide a direct benefit to the wood stork and other wading bird species.

Although the benefits to wood storks of the selected plan is clear from the interpretation of the SFNRC (2013a; STORK1) model, this model may considerably underestimate the benefits of CEPP to storks and other wading birds because it looks only at depths and recession rates. The Beerens (2013) model can also evaluate benefits because it represents critical avian responses to the timing and frequency of multi-annual prey pulses that are a function of much longer-term hydrologic patterns. It can predict when and where resource pulses from optimal periods of inundation will be delivered at the depths at which birds can feed as a function of Depth (linear), Depth (quadratic), Recession (quadratic), Days Since Drydown (DSD), DSD (quadratic), Hydroperiod (linear), Hydroperiod (quadratic), and Depth* DSD. Basically, this model showed that relatively long periods of standing water are necessary to promote sufficient prey production for optimal foraging. It indicates that stork occurrence can significantly decline at a so-called "optimal depth" if wetland inundation is too brief to grow prey populations.

The Beerens model showed improvement in stork habitat conditions in NE Shark Slough with CEPP restoration scenarios, whereas the STORK1 model does not. With CEPP providing greater flows to Shark Slough it will experience longer hydroperiods and DSD, allowing for greater production of fish. This prey production will provide considerably improved foraging habitat in this area. The Beerens (2013) model also showed increases in foraging in Northern WCA-3A (relative to FWO) , with clear improvements during the critical early months.

Restoration of hydroperiods and hydropatterns closer to a pre-drainage condition (Pre-drainage conditions are defined as those conditions that occurred in the late 1800s, prior to the wide-scale drainage, urbanization, and compartmentalization of the Everglades.) is a focal Everglades restoration objective for the Comprehensive Everglades Restoration Plan (CERP). A related CERP restoration goal is to restore historic wading bird foraging and colonial nesting habitats in the mainland estuary zones of Everglades National Park (ENP). Therefore, the general transitioning of wood stork foraging habitat (under most climatic conditions) from Shark River Slough, which historically was a deep water white-water lily-dominated slough habitat, back into southern ENP, is considered a progressive step toward ecosystem restoration.

Hydrologic changes associated with implementation of the project are expected to alter and provide an overall net benefit and significant effect for wood stork foraging suitability throughout WCA 3 and ENP. However, substantial declines in foraging suitability occur in northern ENP due to increased flow deliveries through the Blue Shanty flow way. Implementation of a coordinated adaptive management plan incorporating real-time ground monitoring will also benefit the species.

C.2.2.4.4 Eastern Indigo Snake

The Eastern indigo snake is the largest native non-venomous snake in North America. It is an isolated subspecies occurring in southeastern Georgia and throughout peninsular Florida. The Eastern indigo snake prefers drier habitats, but may be found in a variety of habitats from xeric sandhills, to cabbage palm hammocks, to hydric hardwood hammocks (Schaefer and Junkin 1990). Eastern indigo snakes need relatively large areas of undeveloped land to maintain their population. The main reason for its decline is habitat loss due to development. Further, as habitats become fragmented by roads, Eastern indigo snakes become increasingly vulnerable to highway mortality as they travel through their large territories (Schaefer and Junkin 1990).

In south Florida, the Eastern indigo snake is thought to be widely distributed. Given their preference for upland habitats (Steiner et al. 1983), Eastern indigo snakes are not commonly found in great numbers in the wetland complexes of the Everglades region, even though they are found in pinelands, tropical hardwood hammocks, and mangrove forests in extreme south Florida (Duellman and Schwartz 1958; Steiner et al. 1983). They prefer dry, well drained sandy soils, and commonly use burrows and other natural holes as dens. Steiner et al. (1983) also report that Eastern indigo snakes inhabit abandoned agricultural land and human-altered habitats in south Florida which would include levees within the Water Conservation Areas.

One of the CEPP project features to be constructed is the A-2 FEB. This would convert approximately 14,000 acres of former agricultural land to a wetland functioning area. The proposed A-2 FEB consists almost exclusively of drained marsh that has been converted to agriculture. Currently, the main crop is sugar cane, although rice has also been observed in some fields. A few areas have become overgrown with exotic Brazilian pepper, willow, dog fennel, and grasses including invasive exotic Napier grass. Only two soil types occur in the project area: Pahokee Muck and Lauderhill Muck (NRCS 2012). Both types consist of very poorly drained organic materials that commonly occur in broad freshwater marshes. These soil types indicate hydric soils/wetland areas, which was originally in place prior to human actions. One of the CEPP goals is to help restore lands back to a more natural condition, which in the FEB area, would be considered wetlands.

No natural standing water features are present in the A-2 FEB project area. Natural sloughs and channels are evident in aerial photographs from the 1940s as well as those taken as recently as 2012. These natural sloughs and channels are much drier due to drainage changes, but are the first areas to be inundated during rains. Man-made drainage features such as ditches and narrow canals traverse the A-2 FEB and are continually being modified and created in response to agricultural needs.

Since Eastern indigo snakes occur primarily in upland areas, their presence within the Greater Everglades portion of the project area is somewhat limited. The hydrologic effects of the proposed project are expected to benefit existing or historic wetlands. Once the Miami Canal is backfilled, created tree islands will be constructed, which would potentially provide habitat for the indigo snakes, perhaps offsetting the increased hydroperiods within WCA 3. In addition, improvements to mangrove communities adjacent to Florida Bay may also benefit Eastern indigo snakes within those areas. However, eastern indigo snakes have a high probability of occurrence within the proposed A-2 FEB site and as a result of construction of the A-2 FEB are likely to be displaced, thereby removing approximately 14,000 acres of potential habitat having a significant and unavoidable major adverse effect.

C.2.2.4.5 Florida Manatee

The federally endangered Florida manatee is a large, plant-eating aquatic mammal that can be found in the shallow coastal waters, rivers, and springs of Florida. Florida manatees live in freshwater, brackish, and marine habitats, and can move freely between salinity extremes. Florida manatees have been observed in conveyance canals within the action area, specifically in the lower C-111 Canal just downstream of S-197; and adjacent nearshore seagrass beds throughout Florida Bay including all waters of Card, Barnes, Blackwater, Little Blackwater, Manatee and Buttonwood sounds. The extensive acreages of seagrass beds in the bay provide important feeding areas for Florida manatees. Decreased salinities within the Northern Estuaries that reduce stress on SAV and promote increases in seagrass shoots have the potential to increase foraging opportunities for manatees in this region. Similarly, increased freshwater flows to Florida Bay and the southwestern coastal estuaries resulting in lowered salinity levels that better encompass seagrass salinity tolerance ranges would also increase foraging opportunities for manatees. Alternative 4R2 would provide benefits to Florida manatee as compared with the FWO, providing minor beneficial effects (refer to **Section C.2.1.3.5.2, Seagrass Beds** for further information).

Florida manatees also depend upon canals as a source of freshwater and resting sites. It is highly likely that Florida manatees also depend on the deep canals as a cold-weather refuge. The relatively deep waters of the canals respond more slowly to temperature fluctuations at the air/water interface than the shallow bay waters. Thus, the canal waters remain warmer than open bay waters during the passage of winter cold fronts. **Figure C.2.2-42** illustrates canals that Florida manatees have access to within CEPP action area. All CEPP alternatives include backfilling of portions of the Miami Canal north of Interstate 75. Although **Figure C.2.2-42** shows that manatees can access portions of the Miami Canal, backfilling as described under CEPP is not likely to adversely affect manatees.

Alts 4R and 4R2 would provide increased flows to Florida Bay and the southwestern coastal estuaries, improving salinities, therefore benefitting Florida manatee as compared with the FWO and providing minor beneficial effects. Damaging flows to the Northern Estuaries related to pulse releases would be reduced, resulting in decreased sedimentation and silt, and increased light penetration, therefore providing better sea grass survival and minor beneficial effects. Alt 4R2 includes backfilling portions of the Miami Canal north of Interstate 75, which manatees do access; however, backfilling could benefit them with less likelihood of becoming stranded in the WCAs.

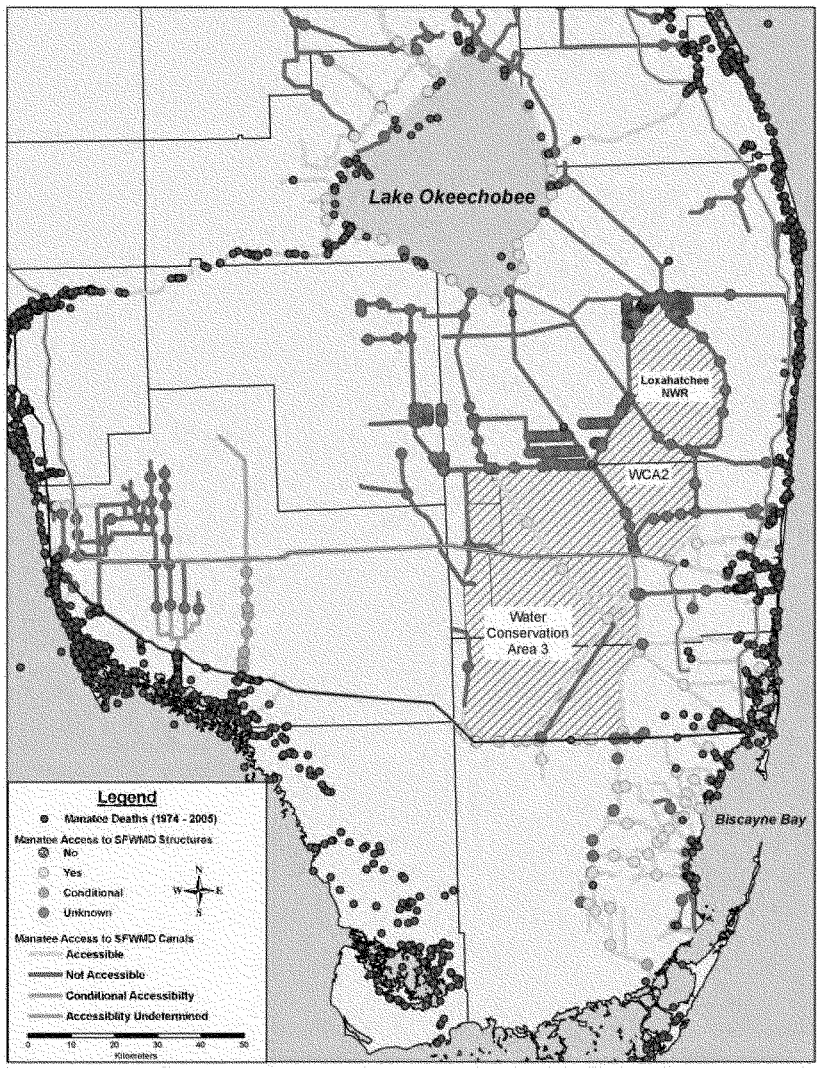


Figure C.2.2-42: Canals that Florida manatee have access to within CEPP action area.

C.2.2.4.6 Florida Panther

The federally endangered Florida panther (*Puma concolor cory)* was once the most widely distributed mammal (other than humans) in North and South America, but it is now virtually exterminated in the eastern United States. Habitat loss has driven the subspecies known as the Florida panther into a small area, where the few remaining animals are highly inbred, causing such genetic flaws as heart defects

and sterility. Recently, closely-related panthers from Texas were released in Florida and are successfully breeding with the Florida panthers. Increased genetic variation and protection of habitat may save the subspecies.

Florida panthers presently inhabit lands in the EAA and ENP adjacent to the Southern Glades, and radio tracking studies have shown that they venture into the Southern Glades on occasion during post-breeding dispersion. Reference is made to the revised Panther Key and Panther Focus Area Map (**Figure C.2.2-43**) for use in determining effects to the Florida panther. Construction of the 14,000 acre FEB within the A-2 parcel in EAA would result in conversion of upland habitat that could be potentially used by Florida panther to transverse the area to wetland habitat, thereby eliminating potential habitat within the panther secondary zone in this region. This would provide a minor adverse effect. In addition, since potentially suitable habitat occurs within the project area, increased water deliveries to ENP could affect Florida panther habitat. However, as lands within the CEPP project area become restored to their more historic natural values, the improved forage base would result in greater use by the Florida panther utilizing these areas, providing a minor beneficial long-term effect.

Today, the A-2 FEB contains agricultural fields planted in sugar cane and rice. Some areas are overgrown with Brazilian pepper, willow, and dog fennel; however, most fields are regularly tilled and disked to a standard depth. This tilling gives the fields a very uniform elevation, which makes observing any variations in the topography difficult. CEPP Alternatives 4R and 4R2 have the potential to affect both the Primary and Secondary Zones for Florida panther habitat.

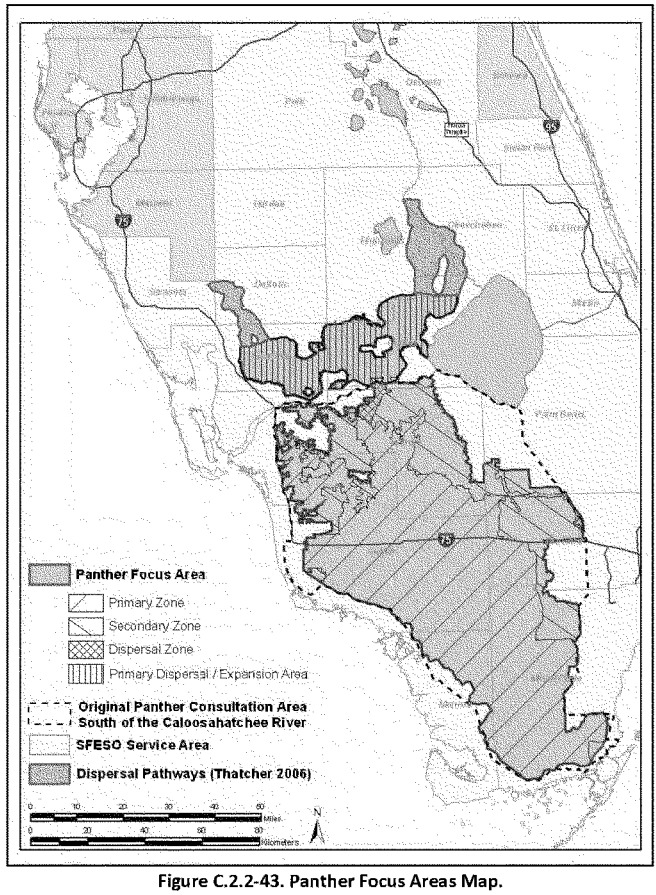


Figure C.2.2-43. Panther Focus Areas Map.

Since potentially suitable habitat occurs within the action area, increased water deliveries under all CEPP alternatives to ENP could affect Florida panther habitat. However, as lands within the study area become restored to their more historic natural values, the concomitant improved prey base would result in greater use by the Florida panther utilizing these areas.

C.2.2.4.7 American Alligator

A keystone species within the Everglades ecosystem, the American alligator (*Alligator mississippiensis*) is dependent on spatial and temporal patterns of water fluctuations that affect courtship and mating, nesting, and habitat use (Brandt and Mazzotti, 2000). Historically, American alligators were most abundant in the peripheral Everglades marshes and freshwater mangrove habitats, but are now most abundant in canals and the deeper slough habitats of the central Everglades. Water management practices including drainage of peripheral wetlands and increasing salinity in mangrove wetlands as a result of decreased freshwater flows has limited occurrence of American alligators in these habitats

(Craighead 1968, Kushlan 1990, Mazzotti and Brandt 1994). A HSI for alligators was employed to predict potential effects of implementation of CEPP Alts 4R and 4R2 (South Florida Natural Resources Center 2013c). The HSI measures habitat suitability annually for five components of alligator production: (1) land cover suitability, (2) breeding potential (female growth and survival from April 16 of the previous year - April 15 of the current year), (3) courtship and mating (April 16 – May 31), (4) nest building (June 15 – July 15), and egg incubation (nest flooding from July 01 – September 15).

Results indicate that implementation of Alts 4R and 4R2 would improve alligator habitat suitability as compared with the FWO and provide a minor beneficial effect. Alligator habitat suitability for Alts 4R and 4R2 trend similarly; differences between alternatives within the project area are negligible. The greatest increase in benefits is visible within northern WCA 3A (CEPP Zones 3A-MC, 3A-NE and 3A-NW) **(Figure C.2.2-44)** due to additional water deliveries within this region. Gains are smaller in central WCA 3A, WCA 3B and ENP north and south zones, though they appear to have an increased spatial extent of slightly improved potential habitat in Alts 4R and 4R2 **(Figure C.2.2-45).** Changes within southern WCA 3A and southeastern ENP are negligible (South Florida Natural Resources Center 2013c). Southern WCA 3A is the only region showing negative impacts to alligator production with Alt 4R (**Figure C.2.2-44**). In summary, increasing freshwater flow through the Greater Everglades into WCA 3 and ENP under CEPP will provide significant increased benefits to alligators within these habitats in comparison with the FWO. Major adverse, significant and unavoidable effects to alligators that utilize the Miami Canal will occur due to backfilling of the Miami Canal. However, these effects are expected to be short-term as alligators will expand into other areas of suitable habitat created as a result of CEPP implementation.

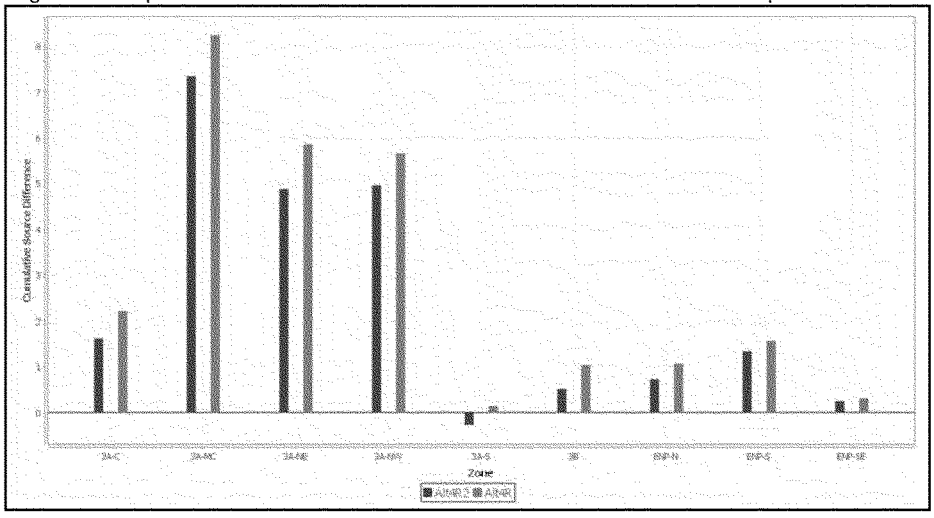


Figure C.2.2-44. Suitable alligator habitat cumulative (1965-2005) lift above the No Action Alternative (FWO) for Alts 4R and 4R2 within each CEPP zone. A maximum score of 41 is possible if FWO has a suitability score of 0.0 every year and the alternative has a suitability score of 1.0 every year. (South Florida Natural Resources Center 2013a).

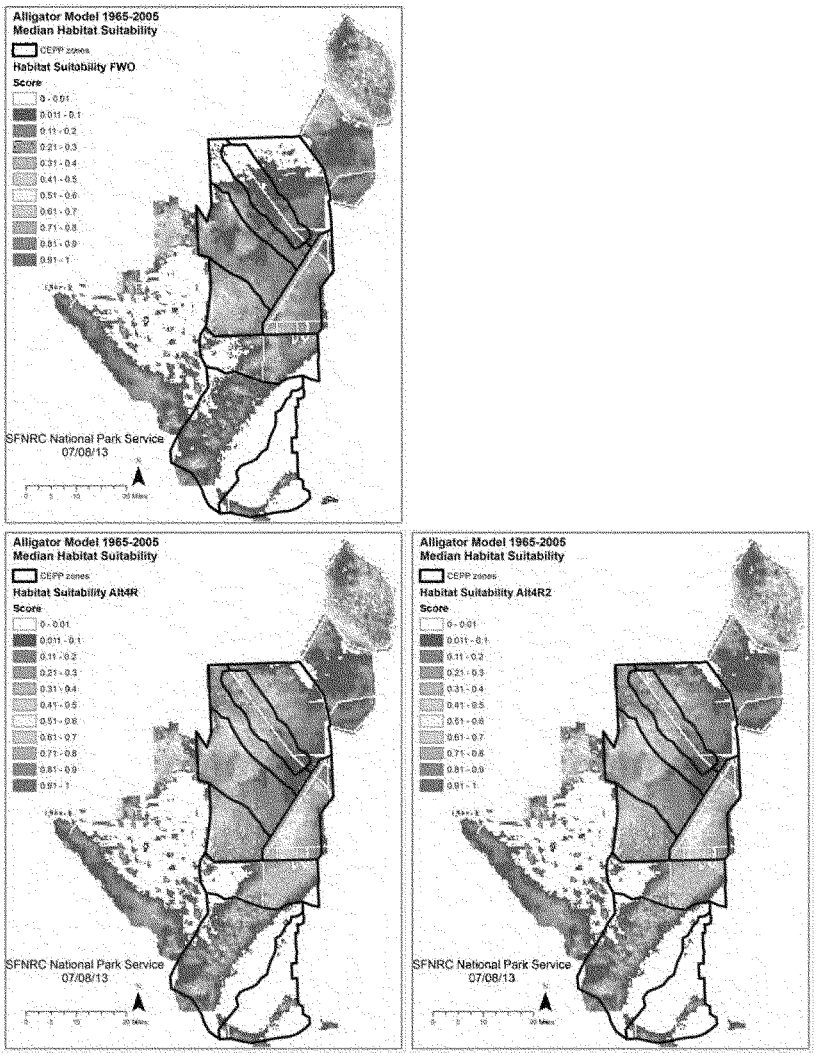


Figure C.2.2-45. Suitable alligator habitat cumulative (1965-2005) lift above the No Action Alternative (FWO) for Alts 4R and 4R2 within each water conservation area (WCA). (South Florida Natural Resources Center 2013a).

C.2.2.4.8 American Crocodile

A HSI for juvenile American crocodiles (*Crocodylus acutus*) was employed to predict potential effects of implementation of CEPP Alts 4R and 4R2. The crocodile growth and survival index used in this analysis is one of the components of a crocodile HSI that characterizes suitable habitat for crocodiles based on habitat, location of known nest sites, salinity, and prey biomass. The growth and survival index is

calculated for August through December, the period following hatching when hatchlings are most vulnerable to high salinities (Moler 1992; Mazzotti 1999; Mazzotti et al. 2007). For this analysis, data from salinity monitoring stations at Joe Bay, Trout Cove, Little Madeira Bay (the stations among the available stations closest to where the highest densities of crocodile nests are) and Long Sound, Little Blackwater Sound, Terrapin Bay and Garfield Bight (generally closer to shoreline stations in areas where crocodiles could occur) are used as input to HSI. Each day between August 1 through December 31 is assigned a score based on the following salinity ranges: salinity <20 practical salinity units (psu) was assigned the highest score of 1 because salinity in this range is considered most favorable for juvenile crocodile growth and survival (Moler 1992; Mazzotti 1999; Mazzotti et al. 2007); salinity $\geq$ 20 and <30 psu was assigned a score of 0.6; $\geq$30 and <40 psu was assigned a score of 0.3, and >40 psu a score of 0. Average yearly and an average overall score were calculated.

Results from applying the salinity data into the juvenile crocodile HSI is shown in **Figure C.2.2-46** (Brandt 2013). The plot shows the lift (Alt 4R minus FWO and Alt 4R2 minus FWO) of an index of juvenile crocodile growth and survival at sites along the northern Florida Bay shoreline for all years of the model runs. Sites in the orange box historically have had the most crocodile nesting. Results of the juvenile crocodile HSI performance for an extremely dry (1989) year are shown in **Figure C.2.2-47**. As indicated by **Figure C.2.2-46** and **Figure C.2.2-47,** implementation of Alts 4R and 4R2 will directly benefit juvenile crocodiles within the CEPP action area, providing a minor beneficial effect.

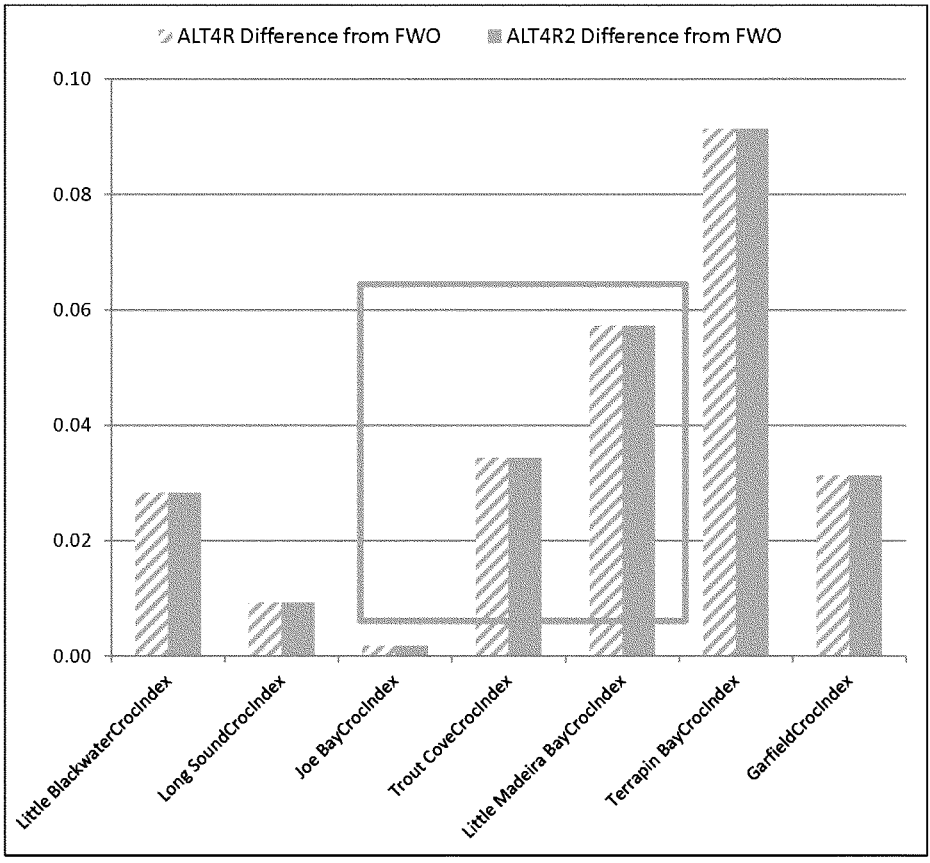


Figure C.2.2-46. Histogram showing the results of the juvenile crocodile HSI for 7 locations of known crocodile nesting areas across all years within Period of Record (1965-2005). Index values show lift provided by Alt 4R as compared with the No Action Alternative and Alt 4R2 as compared to the no action alternative. (Brandt 2013).

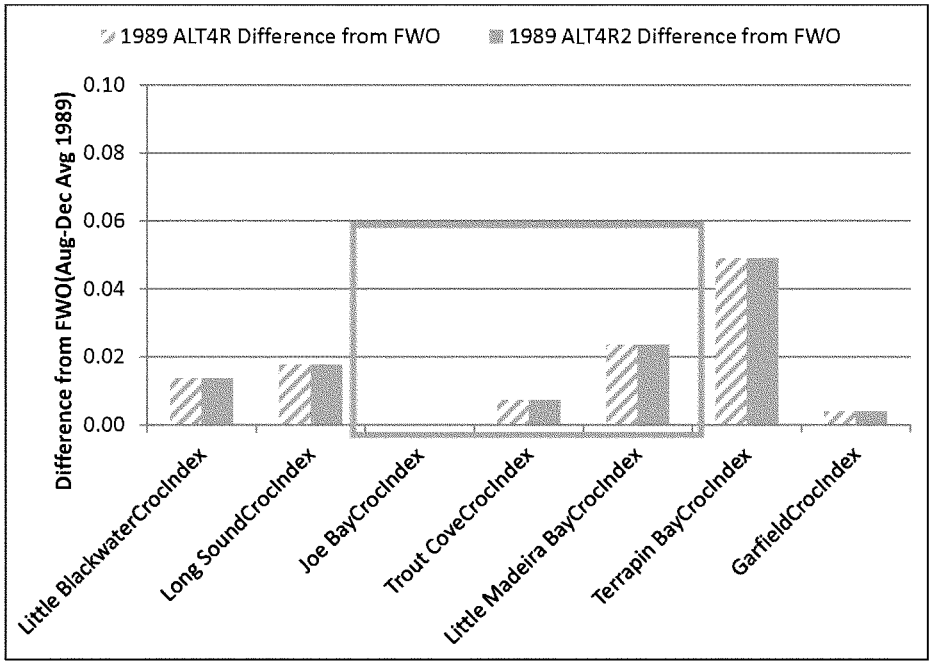


Figure C.2.2-47. Histogram showing the results of the juvenile crocodile HSI for 7 locations of known crocodile nesting areas for a very dry year (1989). Index values show lift provided by Alt 4R as compared with the FWO and Alt 4R2 as compared with FWO. (Brandt 2013).

C.2.2.4.9 Smalltooth Sawfish

Smalltooth sawfish (*Pristia pectinata*) have been reported in the Pacific and Atlantic Oceans, and the Gulf of Mexico; however, the United States population is found only in the Atlantic Ocean and Gulf of Mexico. Historically, the United States population was common throughout the Gulf of Mexico from Texas to Florida, and along the east coast from Florida to Cape Hatteras. The current range of this species includes peninsular Florida, with some regularity only in south Florida from Charlotte Harbor to Florida Bay. Juvenile sawfish use shallow habitats with a lot of vegetation, such as mangrove forests, as important nursery areas. Many such habitats have been modified or lost due to development of the coastal areas of Florida and other southeastern states. The loss of juvenile habitat likely contributed to the decline of this species.

Although the main Florida population resides in the Caloosahatchee River and adjacent Charlotte Harbor estuaries, smalltooth sawfish has the potential to be found in the southern estuaries where the juveniles could potentially occur and feed in red mangrove wetlands. By implementation of the proposed project, the smalltooth sawfish may show a minor beneficial effect from increased freshwater flows into the coastal wetlands adjoining Florida Bay, which would provide more natural and historic overland flows.

Discharging large volumes of freshwater from Lake Okeechobee to the Caloosahatchee River during the wet season significantly reduces salinities and increases nutrient loading; all of which has a profound adverse effect on estuarine flora and fauna. As a result, the smalltooth sawfish may show a minor beneficial effect from the project's ability to reduce excessive freshwater flows by improving the salinity regime throughout the Caloosahatchee estuary.

C.2.2.4.10 Green Sea Turtle

The green sea turtle weighs approximately 150 kilograms and lives in tropical and sub-tropical waters. Areas that are known as important feeding areas for the green turtles in Florida include the Indian River Lagoon, the Florida Keys, Florida Bay, Homosassa, Crystal River and Cedar Key. Green turtles occupy three habitat types: high energy oceanic beaches, convergence zones in the pelagic habitat, and benthic feeding grounds in the relatively shallow, protected waters. Females deposit eggs on high energy beaches, usually on islands, where a deep nest cavity can be dug above the high water line. Hatchlings leave the beach and move in the open ocean. Green sea turtles forage in pastures of seagrasses and/or algae, but small green turtles can also be found over coral reefs, worm reefs, and rocky bottoms.

Although green sea turtles are expected to be found foraging in nearshore seagrass habitats within Florida Bay, the increased freshwater flows associated with CEPP may alter seagrass species composition but should have a negligible and less than significant effect on the overall biomass available for sea turtle feeding habits. Additionally, no green sea turtles would attempt to utilize areas for nesting purposes since there is no suitable habitat for nesting in the project area. With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea Turtle and Smalltooth Sawfish Construction Conditions, the Corps has determined green sea turtle may be affected, but is not likely to be adversely affected, by the proposed project.

C.2.2.4.11 Hawksbill Sea Turtle

The hawksbill sea turtle is a small to medium-sized marine turtle weighing up to 15 kilograms in the United States. The hawksbill lives in tropical and sub-tropical waters of the Atlantic, Pacific, and Indian Oceans. Areas that are known as important feeding areas for hawksbill turtles in Florida include the waters near the Florida Keys and on the reefs off Palm Beach County. Hawksbill turtles use different habitat types at different stages of their life cycle. Post hatchlings take shelter in weed lines that accumulate at convergence zones. Coral reefs are the foraging habitat of juveniles, sub-adults, and adults. They are also known to inhabit mangrove-fringed bays and estuaries, particularly along the eastern shore where coral reefs are absent. Hawksbills feed predominantly on sponges and nest on low and high energy beaches, frequently sharing 94 the high-energy beaches with green sea turtles. Nests are typically placed under vegetation.

Although hawksbill sea turtles are expected to be found foraging near hardbottom habitats within Florida Bay, the increased freshwater flows associated with CEPP may reduce nearshore salinity concentrations but should have a negligible and less than significant effect on sponges or other food sources utilized by this species. Additionally, no hawksbill sea turtles would attempt to utilize areas for nesting purposes since there is no suitable habitat for nesting in the project area. With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea Turtle and Smalltooth Sawfish Construction Conditions, the Corps has determined hawksbill sea turtle may be affected, but is not likely to be adversely affected, by the proposed project.

C.2.2.4.12 Leatherback Sea Turtle

The leatherback sea turtle is the largest living turtle and weighs up to 700 kilograms. The leatherback lives in tropical and sub-tropical waters. Habitat requirements for juvenile and post-hatchling leatherbacks are virtually unknown. Nesting females prefer high-energy beaches with deep unobstructed access. Leatherbacks feed primarily on jellyfish.

Although leatherback turtles are expected to be found foraging in nearshore habitats within Florida Bay, the increased freshwater flows associated with the CEPP may reduce nearshore salinity concentrations but should have a negligible and less than significant effect on jellyfishes or other food sources utilized by this species. Additionally, no leatherback sea turtles would attempt to utilize areas for nesting purposes since there is no suitable habitat for nesting in the project area. With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea Turtle and Smalltooth Sawfish Construction Conditions, the Corps has determined leatherback sea turtle may be affected, but would not likely be adversely affected, by the proposed project.

C.2.2.4.13 Kemp's Ridley Sea Turtle

The Kemp's ridley sea turtle is the smallest of all sea turtles and weighs up to 45 kilograms. This species is a shallow water benthic feeder consuming mainly algae and crabs. Juveniles grow rapidly. Juveniles and sub-adults have been found along the eastern seaboard of the United States and in the Gulf of Mexico. However, the major nesting beach for the Kemp's ridley sea turtle is on the northeastern coast of Mexico. This species occurs mainly in coastal areas of the Gulf of Mexico and in the northwestern Atlantic Ocean. The post-pelagic stages are commonly found dwelling over crab-rich sandy or muddy bottoms. Juveniles frequent bays, coastal lagoons, and river mouths. 95

Although Kemp's ridley sea turtles could be found foraging in nearshore habitats within Florida Bay, this species is not expected to be found within the direct area of influence associated with CEPP. Additionally, no Kemp's ridley sea turtles would attempt to utilize areas for nesting purposes since their main nesting location is on a single stretch of beach on the Gulf Coast of Mexico. With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea Turtle and Smalltooth Sawfish Construction Conditions, the Corps has determined Kemp's ridley sea turtle may be affected, but would not likely be adversely affected, by the proposed project.

C.2.2.4.14 Loggerhead Sea Turtle

Loggerhead sea turtles inhabit the continental shelves and estuarine environments along the margins of the Atlantic, Pacific, and Indian Oceans. Females select high energy beaches on barrier strands adjacent to continental land masses for nesting. Steeply sloped beaches with gradually sloped offshore approaches are favored. After leaving the beach, hatchlings swim directly offshore and eventually are found along drift lines. They migrate to the near-shore and estuarine waters along the continental margins and utilize those areas as the developmental habitat for the sub-adult stage. Loggerheads are predators of benthic invertebrates.

Although loggerhead sea turtles are expected to be found foraging in nearshore habitats within Florida Bay, the increased freshwater flows associated with CEPP may reduce nearshore salinity concentrations but should have a negligible and less than significant effect on crustaceans, mollusks or other invertebrate food sources utilized by this species. Additionally, no loggerhead sea turtles would attempt to utilize areas for nesting purposes since there is no suitable habitat for nesting in the project area.

With the expectation of improved nearshore habitat, no utilization of the project area for nesting purposes, and the implementation of agency approved Sea Turtle and Smalltooth Sawfish Construction Conditions, the Corps has determined loggerhead sea turtle may be affected, but would not likely be adversely affected, by the proposed project.

C.2.2.4.15 State Listed Species

C.2.2.4.15.1 Florida Bonneted Bat

The Florida bonneted bat is Florida's largest bat, weighing approximately 1.1 to 2.0 ounces, with a 19 to 21 inch wingspan, and a body length of 5.1 to 6.5 inches. The species has dark brown fur and large broad ears that join together and slant forward over the eyes. Relatively little is known regarding the ecology and habitat requirements of this species (FWS 2009). In general, bats will forage over ponds, streams and wetlands and require roosting habitat for daytime roosting, protection from predators and rearing of young (Marks and Marks 2008). Florida bonneted bats roost in tree cavities, rocky outcrops and dead palm fronds. In residential communities, the bats roost in Spanish tile roofs, but have also been found in attics, rock or brick chimneys and fireplaces of old buildings (NatureServe 2009). Colonies are small, with the largest reported as just a few dozen individuals. The bat is a nocturnal insectivore and relies upon echolocation to navigate and detect prey. Females give birth to a single pup from June through September (Scott 2004); however limited data suggests that a female may undergo a second birthing season possibly in January or February (FWS 2009).

The Florida bonneted bat is Florida's only endemic bat and is listed by FWC as a state listed endangered species and is a candidate species for Federal listing under the ESA. The range of this species is limited to southern Florida, although this species was encountered in 2008 in two locations within the Kissimmee River Wildlife Management Area north of Lake Okeechobee. Records indicate that it was once common in the 1950s and early 1960s near Coral Gables and Miami (Belwood 1992). The Florida bonneted bat has only been documented in 12 locations within Florida, including areas within Coral Gables, Homestead, Naples, Everglades City and North Fort Myers. Seven of the locations are under public ownership with the Florida bonneted bat found in discrete and specific areas within BCNP, Fakahatchee Strand Preserve State Park, Kissimmee River Wildlife Management Area, Babcock Ranch and Fred C. Babcock and Cecil M. Webb Wildlife Management Area (FWS 2009). Loss of suitable habitat is believed to be the primary cause of population declines. Other perceived threats include pesticide and herbicide use, which decrease populations of insects, the bats primary prey. Given the documented location of the located bats outside of the project area and that increased hydroperiods and wetland area from CEPP implementation should provide for ideal habitat, the Corps determination is that the Florida bonneted bat would not be affected by CEPP.

C.2.2.4.16 State Threatened Species

C.2.2.4.16.1 Everglades Mink

The Everglades mink is an exceedingly rare, small, semi-aquatic mammal. The mink is medium to dark brown in color with dense, glossy, water repellant fur. Minks have a small head with beady black eyes and an elongated body with five partially-webbed toes. Males weigh 2 to 3.5 pounds and are typically two feet in length; females are smaller in size. Minks are nocturnal and generally solitary, except when raising young; three to six kits are born inside the den during the spring and are weaned at five to six weeks. Dens typically consist of a hollow log. Minks are carnivorous, primarily feeding on crayfish, fish, insects, small snakes, small mammals, and birds (Conservancy of Southwest Florida 2009).

The Everglades mink is listed by FWC as a state listed threatened species. Historically, the Everglades mink ranged into the northern Everglades, near the Lake Okeechobee region, but no sightings have been reported in the northern range in recent years. The range of the Everglades mink is currently limited to the shallow freshwater marshes and swamps of ENP, BCNP, and Fakahatchee Strand. Most of the recent sightings of the minks occurred in ENP, near Tamiami Trail (U.S. Highway 41) (Smith 1980).

Seasonal habitat use by the Everglades mink was documented by Humphrey and Zinn (1982) within a large wetland in south Florida (Big Cypress Swamp) using line transects of chalk-dusted trackboards and anal scent attractant. Results indicated a higher frequency of track station visits to marshes in autumn (late wet season) than in spring (late dry season). In the late dry season, most mink track station visits occurred in swamps, where aquatic habitat and high concentrations of prey (fishes) persisted, suggesting that disruptions in the timing and magnitude of water level fluctuations or hydroperiods may negatively impact the species.

The quality of the Everglades mink habitat has been degraded through development and the drainage of wetlands. Unnatural high water levels have also resulted in flooding of dens and an increase in road-related deaths. Suitable freshwater wetland habitat for the species exists within the project area. Evidence of direct impacts to the Everglades mink as a result of the existing operating regime (i.e. ERTP) is lacking, however the species is extremely rare and difficult to trap and/or monitor. IOP has resulted in lower average water levels and shorter periods of surface water inundation in the WCAs to the north of ENP (WCA 3A and WCA 3B), as well as in central and western SRS. Shorter hydroperiods potentially decrease the distribution and abundance of small fish species sensitive to hydrologic changes upon which the Everglades mink feeds. CEPP would increase hydroperiods within WCA 3 and ENP, therefore the Corps determined that CEPP may affect, but is not likely to adversely affect the Everglades mink.

C.2.2.4.16.2 Florida Black Bear

The Florida black bear is one of three subspecies of American black bear recognized in the southeastern United States. The bear is characterized by a highly arched forehead and long narrow braincase. Adult males normally weigh 250 to 450 pounds and females 125 to 250 pounds. Both sexes have soft, black hair, often with blonde chest markings, small round ears, short tails, stout curved claws, and large canine teeth (FWC 2003b). Females give birth every two years, breeding in June and July. Young are born in January and February; litter size is two to four cubs. Females generally first give birth at three to four years of age. Males generally live to be 8 to 12 years old and females 10 to 15 years (FWC 2003b).

Florida black bears may inhabit large tracts of forestland of any type. Habitat includes; pine flatwoods, hardwood swamp, cypress swamp, cabbage palm forest, sand pine scrub and mixed hardwood hammock. Home range sizes vary greatly among individuals, age classes, and populations, but average approximately 37 square kilometers for females and 161 square kilometers for males; individuals tend to be solitary (Maehr and Wooding 1992). Florida black bears are omnivorous, primarily feeding upon vegetation, nuts, berries, and insects. In Florida, black bears are dependent upon saw palmetto plants, black gum, and oak trees for a significant portion of their diet. The species may prey upon animals such as armadillos, deer fawns, and hogs, but overall, these food sources make up a small percentage of their diet (Maehr and Wooding 1992).

The Florida black bear is listed by FWC as a state listed threatened species. Historically, the subspecies ranged throughout the southeastern United States, inhabiting all of Florida, including the upper keys and portions of southern Georgia, Alabama, and Mississippi (FWC 2003b). This widespread distribution has been severely reduced; the range has now been restricted to eight locations within Florida

(Apalachicola, Big Cypress, Eglin, Ocala, Osceola, and St. Johns) and two remnant areas (Chassahowitzka and Glades/Highlands) (FWC 2003b). Unregulated hunting up to the mid 1900s has had the greatest impacts on population declines. More recently, development associated with Florida's growing population has led to an increase in the loss of forested lands and human-induced mortality. The annual number of recorded vehicle/bear collisions and reported human/bear conflicts (nuisance complaints) has risen substantially. CEPP is not expected to negatively affect forested areas, therefore the Corps determination is may affect, not likely to adversely affect the Florida black bear.

C.2.2.4.17 Shore Birds

C.2.2.4.17.1 Snowy Plover, Least Tern, Black Skimmer, and American Oystercatcher

Snowy plovers are small in size, weighing about two ounces, with a 13 inch wingspan, and a length of six to seven inches. Snowy plovers have inconspicuous plumage, with white undersides, pale-brown upperparts, a short black bill, and dark grey to blackish legs (Warriner et al. 199S). Least terns are slightly larger than both, with a wingspan of 20 inches and a length of nine inches. Least terns have a grayish-white body with yellow legs, a short notched tail, and a yellow bill unique among North American terns (Thompson et al. 1997).

The snowy plover and least tern are listed by FWC as state listed threatened species. Florida populations of snowy plovers are made up of both migrant and resident species. Breeding birds are discontinuously distributed along the Gulf coast from Marco Island north to Anclote Key and along the coast of the Florida Panhandle, where most Florida breeders now occur. In central and southern Florida, breeding occurs only in a few protected parks, such as Caladesi Island, Fort DeSo Park, and Cayo Costa and on isolated peninsulas (FWC 2003c). No breeding records exist from the Keys or Atlantic coast. The least tern is more widely distributed than the snowy plover; breeding populations are distributed along both the Gulf and Atlantic Coasts and the Florida Keys (FWC 2003c).

These shorebirds inhabit sparsely vegetated sandy beaches where they nest in shallow depressions on bare, open ground. They typically form loose colonies and require open dry sand near dunes for breeding; access to inner dunes is essential for brood protection (FWC 2003c). For the two species, females typically lay two to three eggs; eggs are incubated for less than 30 days. Nestlings fledge in approximately four weeks and the breeding season extends from March to September (FWC 2003c). Plovers feed on crustaceans, mollusks, marine worms, and insects, by directly capturing prey or by probing in the sand for food. Least terns forage over open water and primarily feed upon small fish and crustaceans.

The numbers and distribution of these shorebirds have steadily decreased due to loss and degradation of coastal habitats and breeding grounds. Continued development of beachfront property into residential, commercial, and recreational areas has led to population declines. Birds quickly abandon nesting attempts when they are disturbed by people. Conservation efforts include closing nesting beaches, monitoring nests, roping off or fencing in breeding sites, posting educational signs and banning pets and vehicle use. CEPP would not affect shorelines, therefore the project would have no effect on the snowy plover, least tern, black skimmer, or American oystercatcher.

C.2.2.4.18 State Listed Species of Special Concern

C.2.2.4.18.1 White Ibis

The white ibis is easily identified by its long red legs, all white plumage, red face, long de-curved red bill and black tipped wings. White ibises are medium-sized wading birds, weighing about two pounds, with a 36-inch wingspan, and a length of 24 inches. White ibises inhabit shallow coastal marshes, wetlands and mangrove swamps and feed on crayfish, crabs, insects, snakes, frogs, and fish (Kushlan and Bildstein 1992).

Nesting occurs in trees, shrubs, and grass clumps from ground level to a height of 50 feet. Nests are constructed of vegetation sticks, leaves, and/or roots. Females typically lay two to three eggs; eggs are incubated for 21 to 22 days. The young are able to leave the nest at 9 to 16 days of age. Nestlings are independent at 40 to 50 days of age. Breeding season extends from March to August (FWC 2003c). Ibises are known for frequent shifts in roost and colony sites.

The white ibis has been recorded to breed throughout the state of Florida; the center of breeding abundance occurs in the Everglades, with breeding populations extending into Florida Bay and the Keys (FWC 2003c). Aerial surveys have revealed 90 percent declines in south Florida breeding pairs since the 1940s and 20 to 50 percent declines statewide during the past decade. Because of this, the FWC listed the white ibis as a state listed species of special concern (FWC 2003c). Population declines of the species are attributed to loss and degradation of suitable habitat; however, large populations of white ibises remain. CEPP would increase hydroperiods, therefore increasing habitat for white ibis as well as increasing the forage base, showing a minor beneficial effect. Therefore the Corps determination is that CEPP may affect, but is not likely to adversely affect the white ibis.

C.2.2.4.18.2 Snowy Egret, Reddish Egret, Little Blue Heron, and Tricolored Heron

The snowy egret, reddish egret, little blue heron, and tricolored heron are listed by the FWC as a species of special concern. Snowy egrets are medium sized herons, with entirely white plumage, long slender black bills, long black legs, and bright yellow feet (Parsons and Masters 2000). The snowy egret breeds in Florida from January through August, breeding mostly in central and southern Florida in freshwater and saltwater marshes (FWC 2003c). The tricolored heron occupies similar habitats; breeding occurs in February through August (FWC 2003c). The tricolored heron is ornately colored; it is slate-blue on its head and upper body and has a purplish chest with white under parts and fore-neck (Frederick 1997).

The little blue heron is a smaller-sized heron, dark overall with yellow-green legs, and a blue bill with a black tip (Rodgers and Smith 1995). The little blue heron shows a preference for freshwater habitat; however, it also inhabits saltwater marshes. Little blue herons breed later than tricolored herons or snowy egrets; breeding occurs in April through September in Florida. The little blue heron is more widely distributed throughout the state in comparison to the tricolored herons or snowy egrets. Like the snowy egret, breeding populations are concentrated in central and southern Florida (FWC 2003c).

Reddish egrets have two color morphs; white and dark. Dark morphs have gray bodies with chestnut heads, blue legs and pink bills with black tips (Lowther and Paul 2002). The reddish egret is the rarest heron in Florida and is entirely restricted to the Florida coast with concentrations in Florida Bay and the Keys; two-thirds of the state's breeding population. The heron forages on shallow flats and sandbars for fish species, including killifish. In Florida Bay, reddish egrets nest from November through May (FWC 2003c).

Population declines of the species are attributed to loss and degradation of suitable habitat. Target nest numbers for snowy egrets and tricolored herons combined are 10,000 to 20,000 pairs. Nesting targets

for the snowy egret and tricolored heron have not been met in the WCAs and ENP since the implementation of IOP in 2002. Nesting effort (number of nests) of these species from 2002 to 2008 is summarized as follows; 2000-2002: 8,614 pairs, 2001-2003: 8,088 pairs, 2002-2004: 8,079, 2003-2005: 4,085 pairs, 2004-2006: 6,410 pairs, 2005-2007: 4,400 pairs, 2006-2008 3,778 pairs(SFWMD 2009b). However, target numbers have not been met prior to the current operating regime; 1998-2000: 2,788 pairs, 1999-2001 4,270 pairs. Little blue heron censuses from aerial surveys are unreliable due to its dark plumage and tendency to nest in small, isolated colonies (FWC 2003c).

CEPP would not negatively affect these bird species. Improved hydroperiods in the WCAs and WNP, CEPP may have a minor beneficial effect, but is not likely to adversely affect the snowy egret, reddish egret, little blue heron, and tricolored Heron.

C.2.2.4.18.3 Limpkin

Limpkins are large (approximately 66 cm) brown to olive colored birds with a long, heavy down-curved yellow bill with a dark tip. Occurring from peninsular Florida and southern Mexico through the Caribbean and Central America to Northern Argentina, limpkins are listed as species of special concern in Florida. Limpkins inhabit freshwater marshes and swamps with tall reeds, as well as mangroves. They are largely nocturnal, but daytime activities have also been observed (Holyoak and Colston 2003).

Limpkins forage primarily in shallow water and on floating vegetation, such as water hyacinth and water lettuce. Similar to Everglade snail kite, this wading bird species feeds primarily on apple snails of the genus *Pomacea*. The availability of apple snails has a significant effect on the local distribution of the limpkin (Cottam 1936). Freshwater mussels and other species of snail are secondary food resources. Less important prey items include insects, frogs, lizards, crustaceans and worms, which may be important dietary components during periods of drought or flooding when birds may be forced to forage in suboptimal areas. Implementation of CEPP would increase hydroperiods, therefore increasing the forage base for the limpkin, providing minor beneficial effects. Therefore, the Corps determination is that CEPP may affect, but is not likely to adversely affect the limpkin.

C.2.2.4.18.4 Roseate Spoonbill

Roseate spoonbills have a pink body with a white neck and breast, pink wings with highlights of red and long reddish legs. Spoonbills have an unfeathered head which can be yellow or green. Roseate spoonbills are large wading birds, weighing about three pounds and have a 50-inch wingspan. Characteristic to the species is a long, spatulate bill. The spoonbill feeds by wading through shallow water, head down, probing the bottom by sweeping its long, spoon-shaped bill back and forth in the water. When prey is detected by touch, the bill snaps shut; small fish, crustaceans, and insects make up the bulk of the diet (Dumas 2000).

Spoonbills typically establish nests in Florida Bay between November 1 and December 15, with a mean nest initiation date of November 18. Females typically lay three eggs; eggs are incubated for about 21 days. After the young spoonbills hatch, chicks require a continuous supply of food for 42 days. Spoonbills primarily feed on wetland fishes. Foraging adult spoonbills require water levels at or below 13 centimeters within the coastal wetlands to forage efficiently and feed young (Lorenz et al. 2010). Nestlings fledge in approximately four weeks (FWC 2003c).

Thirty-nine of Florida Bay's keys have been used by roseate spoonbills as nesting colonies. These colonies have been divided into five distinct nesting regions based on the colonies primary foraging locations: northeast region, northwest region, central region, south region, and southwest region. The

northeast and northwest colonies contain the largest nesting colonies and these birds principally use wetlands on the mainland as their primary foraging grounds (Lorenz et al. 2010). In addition to a large nesting population in Florida Bay, roseate spoonbills historically nested along the southwest coast of the Everglades in the SRS and Lostman's Slough estuaries. Although there has been some documentation of spoonbill nesting in this area, the numbers have been negligible (Lorenz et al. 2009).

The roseate spoonbill is state listed by the FWC as a species of special concern. In 1979, 1,258 roseate spoonbill nests were located in Florida Bay. More than half of these nests (688) were located in the northeast region (Lorenz et al. 2008). Drops in nests coincide with the completion of the South Dade Conveyance System (SDCS) in 1982, when water deliveries to Taylor Slough and northeastern Florida Bay changed dramatically. Since completion of the SDCS, spoonbill nesting effort has shifted to the northwest region of Florida Bay; nesting effort has been consistent since the early 1980s and the population remains stable with an average of 1.24 chicks produced per nest, per year (Lorenz et al. 2008). Prior to the construction of the SDCS, spoonbills in the northeast region of Florida Bay produced an average of 1.38 chicks per nest, per year. Following completion of the SDCS, spoonbill production dropped to 0.67 chicks per nest, per year (Lorenz et al. 2008). Wading bird studies suggest that a population that does not produce at least one chick per nest, on average, will decline. CEPP is expected to benefit wading bird populations with an increased forage base. Therefore, the Corps determination is that CEPP may provide minor beneficial effects, but is not likely to adversely affect the roseate spoonbill.

C.2.2.5 Wildlife

A comparison of the FWO and CEPP action alternatives Alt 4R and 4R2 and their potential effects on wildlife within the CEPP action area are summarized below. Effects to state and federally listed species are described in further detail in **Section C.2.2.4, Threatened and Endangered Species** and within **Annex A**. Changes in water quality also have the potential to affect prey forage base through altering of vegetation composition or structure. Water quality will continue to be monitored under CEPP; potential effects are largely uncertain at this time.

C.2.2.5.1 Invertebrates

Negligible and less than significant effects to the invertebrate community within Lake Okeechobee or EAA are anticipated with CEPP implementation. Currently, many oyster beds are stressed and have been reduced or eliminated from their former areas by extreme salinity fluctuations, increased turbidity, sedimentation, dredging and damage from boats. Oyster beds have been stressed and occasionally all but eliminated by frequent freshwater releases from both the watershed and Lake Okeechobee. During dry times, oysters in the Caloosahatchee are also stressed by disease and increased predation due to higher salinities. As compared with the FWO, Alts 4R and 4R2 show a minor beneficial effect with performance improvement within the Northern Estuaries as indicated by fewer high volume flow months. Reductions in high volume discharges and salinity fluctuations would likely benefit oysters within the Northern Estuaries. Reduction in high flows and accompanying flow velocities would help lessen the current problem of flushing of oyster spat into outer areas of the Northern Estuaries that experience high salinities levels during the dry season resulting in increased predation and disease in the oyster population.

Within Florida Bay, a habitat suitability index model was employed to simulate growth, survival and potential harvest of a cohort of shrimp as a function of salinity and temperature (Browder et al. 1999; 2002). Comparisons of the percent increase in potential pink shrimp harvest in two representative Florida Bay basins over the 41-year POR for Alts 4R and 4R2 relative to the FWO are shown in **Figure C.2.2-48** and **Figure C.2.2-49**. Whipray Basin is located in north central Florida Bay and Johnson Key

Basin is located in western Florida Bay. Alt 4R2 provides slight improvement relative to Alt 4R in both Whipray Basin and Johnson Key Basin and provides minor beneficial effects.

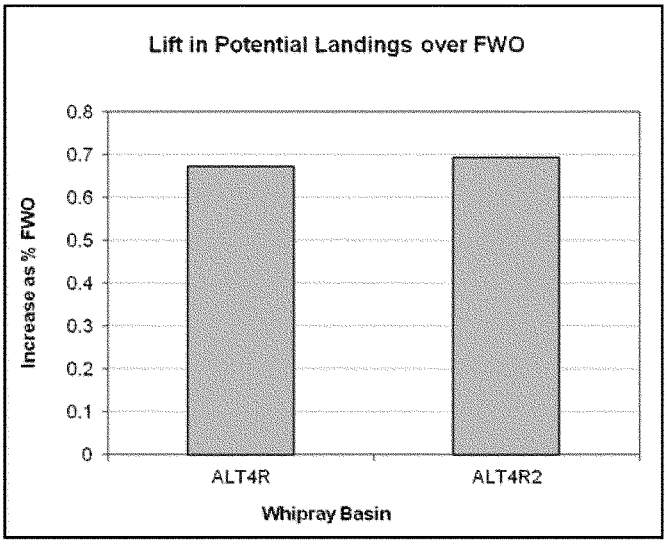


Figure C.2.2-48. Comparison of the percent increase in potential pink shrimp harvest in Whipray Basin for the 1965-2005 period of record for Alts 4R and 4R2 relative to the No Action Alternative (FWO). (Browder 2013).

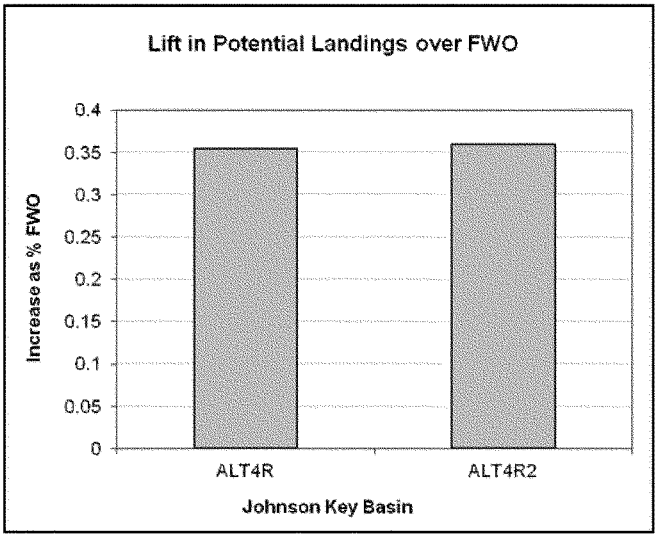


Figure C.2.2-49. Comparison of the percent increase in potential pink shrimp harvest in Johnson Key Basin for the 1965-2005 period of record for Alternatives 4R and 4R2 relative to the No Action Alternative (FWO). (Browder 2013).

In Biscayne Bay, Alt4R provided less water while Alt4R2 provided additional flows when compared to FWO. Alt4R flows to the coast are not evenly distributed showing positive benefits in the very northernmost reach of Biscayne Bay and minor adverse effects from the mid-section of the northern portion to the south. Alt4R2 provides additional flows throughout the bay and is likely to provide a minor beneficial effect to the invertebrate population by providing additional flows to the coast, thereby lowering salinity levels and/or reducing the number of days salinities exceed 40 psu. Alt4R would likely result in a significant and negative effect to the invertebrate population by increasing the likely hood of maintaining salinity conditions in Biscayne Bay above the preferred salinity range of invertebrate population for longer periods of time than FWO. Alternative 4R shows an unfavorable seasonal flow pattern with reductions in flows compared to FWO generally greater during the dry season. Alt4R2 shows slightly increased flows patterns for both seasons compared to FWO.

Within the Greater Everglades aquatic invertebrates would rapidly colonize newly re-hydrated areas with implementation of Alts 4R and 4R2, showing a minor beneficial effect that directly benefits aquatic invertebrates within the action area. Increases in stages and hydroperiods within WCA 2, northern WCA 3A, WCA 3B and ENP would promote wetland vegetation transition through contraction of sawgrass marshes and expansion of wet prairies, and in deeper regions, sloughs. Submerged aquatic plants are commonly associated with sloughs providing structure for growth of periphyton, the main source of primary production within the freshwater Everglades (Gunderson 1994; Powers 2005).

Periphyton is a primary component of invertebrate diets, including apple snails. In addition to the potential for increased foraging opportunities, changes in vegetation resulting in expansion of wet prairie and increases in emergent vegetation would also provide habitat structure critical for apple snail aerial respiration and egg deposition (Turner 1996; Darby et al. 1999). Apple snails tend to avoid areas where water depths are greater than 50 centimeters (Darby et al. 2002). Avoidance of deeper depths may be related to the type and density of vegetation in deeper water areas, food availability or energy requirements for aerial respiration (van der Walk et al. 1994; Turner 1996; Darby 1998; Darby et al. 2002). Water-lily sloughs support lower apple snail densities as compared with wet prairies (Karunaratne et al. 2006). Limited food quality and lack of emergent vegetation in sloughs may account for the lower densities. Research indicates that apple snails depend upon periphyton for food (Rich 1990; Browder et al. 1994; Sharfstein and Steinman 2001), which may be limited within deeper water environments. Karunaratne et al. (2006) observed little or no submerged macrophytes and epiphytic periphyton in the sloughs they studied in WCA 3A. In contrast, species commonly encountered within wet prairie habitat (e.g. *Eleocharis* spp., *Rhynchospora tracyi*, *Sagittaria* spp.), along with sawgrass that grows within the ecotones between the two vegetative communities, support abundant populations of epiphytic periphyton (Wetzel 1983; Browder et al. 1994; Karunaratne et al. 2006). A reduction in the number of available emergent stems for egg deposition would also contribute to the observed lower snail densities within sloughs. Drying events are needed to maintain the emergent plant species characteristic of typical apple snail (Wood and Tanner 1990; Davis et al. 1994). As shown by Darby et al. (2008), apple snails can survive these events and it is the timing and duration of the dry down event that are critical determinants of apple snail survival and recruitment. As compared with the FWO, Alts 4R and 4R2 provide increased opportunities for apple snails within northern WCA 3A; and appropriate conditions for increased apple snail populations in ENP and provide minor beneficial effects (see **Section C.2.2.4.1** for more information on apple snails).

Crayfish are important components within the Everglades food web, serving as primary dietary components of higher trophic level species including fish, amphibians, alligators, wading birds and mammals such as raccoons and river otters (Kushlan and Kushlan 1979). Crayfish are particularly important forage resource for nesting white ibis (*Eudocimus albus*), therefore the availability of crayfish is an important component for recovery of this species (Boyle et al. 2012; Dorn et al. 2011). Crayfish species composition and abundance within the Greater Everglades are linked to hydroperiod. Two species of freshwater crayfish are found within the Greater Everglades: Everglades crayfish (*Procambarus alleni*) and slough crayfish (*Procambarus fallax)*. *P. alleni* is commonly found in marshes that dry seasonally, generally with a hydroperiod of less than 10 months. When surface water recedes, *P. alleni* burrows to escape drying conditions. *P. fallax* is commonly found in perennially flooded habitats. Both species have been found co-occurring in areas with hydroperiods ranging between 9 and 11 months, as well as in sites that remained flooded during the dry season.

Increases in hydroperiod associated with implementation of Alts 4R and 4R2 would likely increase crayfish density within areas of northern WCA 3A, WCA 3B and ENP, particularly within the marl prairies providing a moderate and significant beneficial effect. Research by Acosta (2001) revealed that environmental changes associated with shortened hydroperiod have affected growth, survival, dispersal and productivity within Everglades marl prairies and within the rocky glades. Results from this study indicate that crayfish productivity would increase substantially if hydroperiods within marl prairies wetlands were extended by 3 to 4 months. Although CEPP would not extend hydroperiods within marl prairies by this duration, Alts 4R and 4R2 would increase hydroperiods within this region resulting in increased *P. alleni* productivity.

P. alleni biomass also declines during periods of extended high water. During extended periods of inundation, populations of large predatory fish species may increase, thereby increasing predation pressure on crayfish populations (Kushlan and Kushlan 1979). Under CEPP, in areas in which hydroperiods will be extended sufficiently to support increases in large predatory fish (refer to **Section C.2.2.5.2**, **Fish**), there will also likely be associated declines in *P. alleni* biomass.

Kushlan and Kushlan's (1979) notion that dry-downs promote crayfish abundance and recruitment by reducing predatory fish populations has recently received considerable empirical support for both crayfish species. Kellogg and Dorn (2012) demonstrated that just a few small sunfish (*Lepomis* spp.) can have dramatic effects on crayfish recruitment in experimental wetland mesocosms. Moreover, this was verified at the slough scale in an experimental drought study at LILA (SFER 2012), and at the scale of WCA 3A where crayfish densities were positively correlated with the length of the previous dry period (SFER 2012). Taken together, these results suggest aquatic predators control crayfish density and recruitment and dry disturbances, which temporarily reduce predatory fishes, release crayfish from top-down control. However, it should also be noted that deep water refuges (e.g. canals) buffering predatory fish populations against drying, and poor burrowing substrates for crayfish (i.e., shallow peat layers combined with long dry periods) can offset the positive effects of dry disturbances for crayfish population growth. Thus, while CEPP is likely to improve conditions for crayfish in areas that are currently too dry for crayfish production (sensu Acosta 2001), it is not entirely clear how additional water provided by Alts 4R and 4R2 will affect populations in areas that currently experience periodic dry downs and are relatively productive for crayfish.

C.2.2.5.2 Fish

Implementation of CEPP is expected to significantly improve conditions for fish species throughout much of the Greater Everglades and have a moderate and significant beneficial effect. It is predicted that with implementation of Alts 4R and 4R2, that the largest percent gains in daily average fish density would occur within northern WCA 3A and NESRS due to rehydration. In these areas, fish densities often increased in excess of 20%, with extremes of over 50% (**Figure C.2.2-50**). Other areas within Shark River Slough are also expected to experience appreciable gains in fish density due to increased flows. It is also expected that regional percent changes in fish densities would be highest in SRS and the southern marl prairies (17-31%) for Alt 4R and that Taylor Slough and Florida Bay would also be expected to experience positive changes as compared with the FWO (Catano and Trexler 2013). Alt 4R predicted approximately 5% higher biomass than Alt 4R2 in SRS and the southern marl prairies. Decreases in fish density, or negligible changes (3%), were predicted for Alts 4R and 4R2 in WCA 2A and the area of WCA 3A along the L-67 A canal. Negligible differences between Alts 4R and 4R2 were predicted in most other regions.

Introduction or expansion of non-native fish species due to changes in water distribution and increased connectivity within WCA 3A, WCA 3B and ENP is likely to occur; however, the extent of invasion is uncertain at this time. In contrast to the FWO, new access points will be created under CEPP.

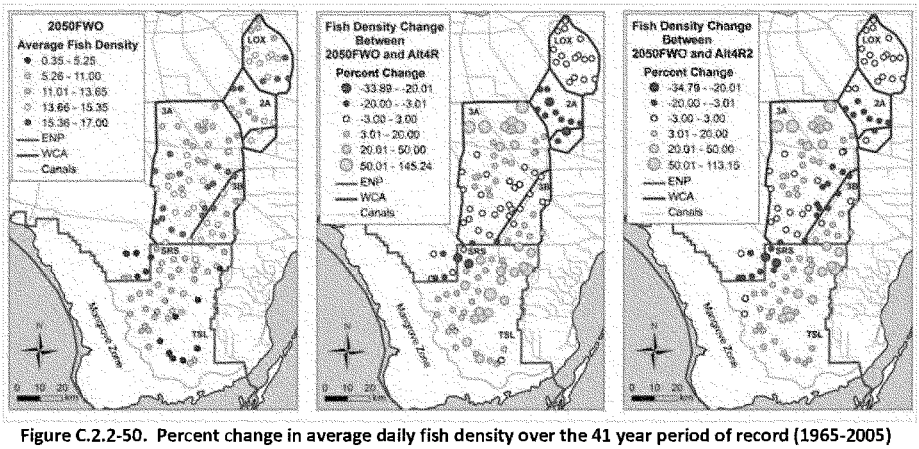


Figure C.2.2-50. Percent change in average daily fish density over the 41 year period of record (1965-2005) predicted by comparing the No Action Alternative to Alts 4R and 4R2. Bubble sizes are proportional to differences in density.

In Biscayne Bay, Alt4R provided less water while Alt4R2 provided additional flows when compared to FWO. Alt4R flows to the coast are not evenly distributed showing positive benefits in the very northernmost reach of Biscayne Bay and negative effects from the mid-section of the northern portion to the south. Alt4R2 provides additional flows throughout the bay and is likely to provide a benefit to the fish population by providing additional flows to the coast, thereby lowering salinity levels and/or reducing the number of days salinities exceed 40 psu, providing minor beneficial effects. Alt4R would likely result in a minor adverse effect to the fish population by increasing the likely hood of maintaining salinity conditions in Biscayne Bay above the preferred salinity range of fish population for longer periods of time than FWO. Alternative 4R shows an unfavorable seasonal flow pattern with reductions

in flows compared to FWO generally greater during the dry season. Alt4R2 shows slightly increased flows patterns for both seasons compared to FWO.

C.2.2.5.3 Amphibians and Reptiles

Minor beneficial effects to amphibian and reptile communities are anticipated with CEPP implementation. Alts 4R and 4R2 showed improved conditions for amphibians within WCA 3 and ENP as compared with the FWO. Rehydration within previously dry areas within northern WCA 3A would increase spatial extent of suitable habitat for aquatic amphibian species in this area. Similarly, increased hydroperiods within ENP would also benefit aquatic amphibian species. As hydrology improves within WCA 3A, WCA 3B and ENP, it is expected that amphibian species richness will also change. However, declines in some amphibian species will be offset by favorable habitat conditions for other species. Increase in forage prey availability (i.e. crayfish and other invertebrates, fish) in areas rehydrated by CEPP implementation will also directly benefit amphibian and reptiles species.

Introduction or expansion of non-native amphibian species due to changes in water distribution and increased connectivity within WCA 3A, WCA 3B and ENP is likely to occur and have a minor adverse effect; however, the extent of invasion is uncertain at this time. In contrast to the FWO, new access points will be created under CEPP.

Submerged aquatic vegetation and algal communities are also common foraging areas for the green sea turtle. Decreased salinities within the Northern Estuaries that reduce stress on SAV and promote increases in seagrass shoots have the potential to increase foraging opportunities for green sea turtles in this region. Similarly, increased freshwater flows to Florida Bay and the southwestern coastal estuaries resulting in lowered salinity levels that better encompass seagrass salinity tolerance ranges would also increase foraging opportunities for green sea turtles. Alt 4R2 provided slightly improved salinity conditions in Florida Bay in comparison to Alt 4R. Implementation of Alts 4R and 4R2 would directly benefit foraging green sea turtles within the Northern and Southern Estuaries and provide a minor beneficial effect.

C.2.2.5.4 Birds

The freshwater wetlands of the Everglades are noted for their abundance and diversity of colonial wading birds. Nesting and foraging activities of resident bird species are anticipated show a moderate beneficial effect with the implementation of Alts 4R and 4R2. Impacts to the Cape Sable seaside sparrow, snail kite, and word stork are further discussed in **Section C.2.2.4, Threatened and Endangered Species** (see also **Annex A** for the BA). Changes in water quality also have the potential to affect birds through alteration of vegetation composition or structure or impacts to their forage base. Water quality will continue to be monitored under CEPP and potential effects are largely uncertain at this time.

As predicted by the Trophic Hypothesis (RECOVER 2004) an increase in density of small fishes will directly benefit higher trophic level predators such as wading birds. Therefore, it is predicted that Alts 4R and 4R2 that provide a moderate beneficial effect to small fishes as described in **Section C.2.2.5.2, Fish**, will also perform well overall for wading birds. Crayfish are a particularly important forage resource for nesting white ibis (*Eudocimus albus*). Appropriate foraging conditions and crayfish densities within core foraging areas of nesting wading birds colonies can reduce foraging flight distance. As indicated in **Section C.2.2.5.1, Invertebrates**, increases in hydroperiod associated with implementation of Alts 4R and 4R2 would likely increase crayfish density within northern WCA 3A, WCA 3B and ENP, particularly within the marl prairies.

The largest wading bird rookery within the Everglades ecosystem is Alley North. Under current and FWO conditions, a large dry area within northeastern WCA 3A creates a significant hazard for nesting birds due to egg predation by mammals. Alts 4R and 4R2 show significant hydrological improvement within northeastern WCA 3A, providing minor beneficial effects. As compared to Alt 4R, Alt 4R2 showed slightly lower depths during average hydrologic conditions in northeastern WCA 3A. Associated increased depths, hydroperiods and sheetflow decrease the potential for nest predation within Alley North.

C.2.2.5.5 Mammals

As compared with the FWO, potential minor beneficial effects to mammals within the CEPP action area are anticipated with Alts 4R and 4R2. Small mammals including raccoons and river otters would benefit from increased crayfish and small prey fish biomass in rehydrated areas within northern WCA 3A, WCA 3B and ENP as a result of Alts 4R and 4R2. Effects to state and federally listed species are described in further detail in **Section C.2.2.4, Threatened and Endangered Species** and within **Annex A**. Changes in water quality also have the potential to affect prey forage base through altering of vegetation composition or structure. Water quality will continue to be monitored under CEPP; potential effects are largely uncertain at this time.

CEPP implementation, however, may have a short-term significant, adverse and unavoidable effect on mammals dependent upon upland habitat. As compared with the FWO, Alts 4R and 4R2 increased depths and resulting hydroperiods within northern WCA 3A. Due to increased water flow and changes in water distribution it is anticipated that overdrained areas in northern WCA 3A will be rehydrated, triggering a vegetation transition from upland to wetland habitat. Performance between Alts 4R and 4R2 was similar in northwestern WCA 3A; however Alt 4R2 showed slightly lower depths during average hydrologic conditions in northeastern WCA 3A. Although, mammals occurring within the action area are adapted to the naturally fluctuating water levels in the Everglades; there is an increased potential for this vegetation transition to have a short-term significant, adverse effect on the mammals utilizing upland habitat. This is a particular concern for deer populations within northern WCA 3A that utilize tree islands. However, as discussed in **Section C.2.2.3.4.4, Tree Islands**, no adverse effects to tree islands within WCA 3A and ENP are anticipated to occur under any CEPP implementation; however slightly lower water depths under Alt 4R2 relative to Alt 4R may be more favorable to deer populations in northeastern WCA 3A. Deer populations that utilize the lower elevation tree islands within WCA 3B may suffer from habitat loss, having a short-term significant, adverse and unavoidable effect. In addition, deer that utilize levees slated for removal (L-67A, L-29, L-67 Extension) also have the potential to show a moderate adverse effect. Loss of these levees may be offset by the construction of the Blue Shanty Levee in WCA 3B. Deer are highly mobile and will migrate to find suitable habitat. Negligible effects on mammals in the remainder of the CEPP action area are anticipated under Alts 4R and 4R2.

C.2.2.6 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act, 16USC 1801 et seq. Public Law 104-208 reflects the Secretary of Commerce and Fishery Management Council authority and responsibilities for the protection of essential fish habitat (EFH). Federal agencies that fund, permit, or carry out activities that may adversely impact EFH are required to consult with the National Marine Fisheries Service (NMFS) regarding the potential effects of their actions on EFH. In conformance with the 1996 amendment to the Act, the information provided in this Integrated Environmental Impact Statement (EIS) will comprise the required EFH assessment and has been coordinated with NMFS.

Consultation for CEPP was initiated on January 10, 2012 through a NEPA scoping letter. The NMFS has indicated that beneficial effects to fish resources and EFH may occur as a result of this project. The NMFS requested an evaluation of potential impacts to living marine resources, including mangroves, seagrasses, live bottom communities, and the marine/estuarine water column that may be impacted by activities or operations of the project alternatives.

Essential Fish Habitat in the Project Area:

The project area includes three distinct regional estuarine and nearshore coastal systems: The southern estuaries including Biscayne Bay and Florida Bay; and the northern estuaries including the Caloosahatchee River and the St. Lucie Estuary.

The southern estuaries comprise Biscayne National Park and a large portion of Everglades National Park, and are a shallow estuarine system (average depth less than 3 feet). Florida Bay is the main receiving water of the greater Everglades, heavily influenced by changes in timing, distribution, and quantity of freshwater flows into the southern estuaries. Lake Okeechobee discharges into the two northern estuaries. The St. Lucie Canal feeds into the St. Lucie Estuary, and the Caloosahatchee Canal/River feeds into the Caloosahatchee Estuary to the west.

Biscayne Bay and Florida Bay

The southern estuaries contain essential fish habitat for corals; coral reef and live bottom habitat; red drum (*Sciaenops ocellatus*); penaeid shrimps; spiny lobster (*Panulirus argus*); other coastal migratory pelagic species and the snapper-grouper complex. Species generally present in the southern estuaries region include brown shrimp (*Penaeus aztecus*), pink shrimp (*Penaeus duorarum*), white shrimp, spiny lobster, stone crab, gulf stone crab, red drum, Spanish mackerel, and gray snapper (*Lutjanus griseus*). Essential fish habitat in the southern estuaries is comprised of seagrasses, estuarine mangroves, intertidal flats, the estuarine water column, live/hard bottoms, and coral reefs.

Caloosahatchee River

The Caloosahatchee River estuary contains essential fish habitat for juvenile brown shrimp (*Penaeus aztecus*), juvenile gray snapper (*Lutjanus griseus*), juvenile pink shrimp (*Penaeus duorarum*), adult and juvenile red drum, (*Sciaenops ocellatus*), adult and juvenile Spanish mackerel (*Scomberomorus maculatus*), smalltooth sawfish (*Pristia pectinata*) and juvenile stone crab (*Menippe mercenaria*). Downstream habitats include oyster reefs and seagrass beds (submerged aquatic vegetation).

St. Lucie Estuary

The proposed project is within the jurisdiction of the South Atlantic Fishery Management Council (SAFMC) and is located in areas designated as EFH for wormrock, live bottom habitat, for the American oyster (*Crassostrea virginica*); pink shrimp (*Penaeus duorarum*); white shrimp (*Penaeus* sp.) and brown shrimp (*Penaeus aztecus*); Florida red drum (*Sciaenops ocellatus*); grouper (*Epinephelus* spp.); gray snapper (*Lutjanus griseus*); white grunt (*Haemulon plumieri*); red porgy (*Pagrus pagrus*); spiny lobster (*Panulirus argus*); and the snapper-grouper complex. In addition, the nearshore hardbottom habitat outside of the St. Lucie Estuary is designated as Essential Fish Habitat-Habitat Areas of Special Concern (EFH-HAPC) for the snapper-grouper complex.

Assessments of Effects on Essential Fish Habitat:

Southern Estuaries

Project construction activities should have no effect on the nearshore communities or essential fish habitat downstream of the project areas. However, this project is expected to have a minor beneficial

indirect effect by increasing overland flow into the southern estuaries. The increased flow is anticipated to stabilize the water quality and salinities required to improve and sustain nearshore biological communities.

Seagrasses are expected to benefit from the re-direction and dispersion of fresh water across the wetland systems prior to entering the southern estuaries. Seagrass habitats are heavily utilized by both juvenile and adult fishes and invertebrates for feeding and shelter (SAFMC 1998). Species that depend on seagrass habitats include the penaeid pink and brown shrimp, and spiny lobster (SAFMC 1998). Seagrass performs as an important nursery habitat for red drum, snook (*Centropomus undecimalis*), bonefish (*Albula vulpes*), tarpon (*Megalops atlanticus*) and several species of snapper and grouper, and is critical to the health of Biscayne Bay, Florida Bay, and a number of commercial and recreational fisheries (SAFMC 1998).

The restored hydrology provided by this project would also increase the periodic inundation of the downstream mangrove wetlands. Mangrove wetlands depend on this periodic inundation; the lack of freshwater from upstream sources contributes to their degradation (SAFMC 1998). Mangrove habitats are important because they provide food and refuge to a large variety of species. These species include: spiny lobsters, pink shrimp, snook (*Centropomus undecimalis*), goliath grouper (*Epinephelus itajara*), tripletail (*Lobotes surinamensis*), leatherjack (*Oligoplites saurus*), gray snapper (*Lutjanus griseus*), dog snapper (*L. jocu*), sailor's choice (*Haemulon parra*), bluestriped grunt (*H. sciurus*), sheepshead (*Archosargus probatocephalus*), black drum (*Pogonias cromis*) and red drum (SAFMC 1998).

The estuarine water column is typically characterized by four salinity categories: oligohaline (< 8 psu), mesohaline (8-18 psu), and polyhaline waters (18-30 psu) with some euhaline water (>30 psu) around inlets (SAFMC 1998). Saline boundaries in the estuarine water column are variable, but are generally maintained by sea water transported through inlets by tide and wind mixing with fresh water supplied by land runoff' (SAFMC 1998). This project will improve quantity, timing, and distribution of water delivered to Northern Biscayne Bay and Eastern Florida Bay, providing a minor beneficial effect. It is likely that this will result in an improvement to the salinity characteristics of the estuarine water column. This habitat is utilized by larvae of commercially important fishes for feeding, and is an important means of conveying organisms and nutrients from inland to offshore areas (SAFMC 1998).

This project is not expected to have an effect on coral reef or hard bottom communities in the southern estuaries. There are no coral reefs or hard bottom communities located within the proposed project site or the nearshore waters affected by the project. Corals found within Florida Bay and Biscayne Bay are outside the area of potential effect.

Northern Estuaries

Aquatic habitats within the Caloosahatchee Basin have been altered through the channelization of the river. Nevertheless, the basin continues to support fishery resources of some recreational and commercial importance. Seagrass communities within the Caloosahatchee estuary provide critical refugia for juvenile fishes such as redfish, grouper, snook, and spotted seatrout. The decline in juvenile abundance and distribution of these and other species, along with an overall decrease in species richness may be related to the loss of seagrass habitat and/or a result of alterations in the salinity regime and the timing of the freshwater discharges from the S-79 structure. Reports from Lee County biologists (e.g. J.N. Ding Darling National Wildlife Refuge, City of Sanibel, and the Sanibel Captiva Conservation Foundation), indicate seasonal seagrass die-offs (as observed under the present freshwater plume extending beyond the mouth of the lower estuary); and given the appropriate salinity

conditions, seagrass growth and spatial expansion. However, while difficult to quantify the mortality and subsequent impacts to estuarine organisms including oysters and fishes, reductions and durations of high volume freshwater discharges into the Caloosahatchee River as a result of implementing CEPP will help maintain salinities in the preferred ranges for all estuarine biota.

Another primary goal of this project is to reduce high nutrient freshwater flows to the St. Lucie estuary. No direct impacts are anticipated, rather the restoration potential of seagrass beds, oyster reef, and the estuarine water column itself. Increases in seagrass and oyster reef would provide a large number of benefits to the essential fish habitat species. The proposed project significantly increases the acres of SAV, oyster, and healthy benthic habitat, providing a minor beneficial effect.

Conclusion:

Southern Estuaries

Previous water management operations have resulted in an inland migration of saline conditions in both groundwater and surface waters. This has caused the expansion of moderate to high salinity zones and has diminished the spatial extent of freshwater wetland habitats in the southern estuaries. Landward expansion of saltwater and mangrove wetlands, including low-productivity, sparsely vegetated dwarf mangrove communities typical of the hypersaline 'white zone' has also occurred in the southern estuaries.

The proposed project components would improve freshwater delivery to coastal wetlands and adjacent southern estuaries. Implementation of the project would redistribute flow to salt water wetlands and nearshore bay areas and result in favorable changes to salinity levels. These changes may affect essential fish habitat, although the impacts to the aquatic resources are anticipated to be significant and beneficial.

Northern Estuaries

The Caloosahatchee and St. Lucie estuaries both receive excessive discharges from Lake Okeechobee as well as their local basins during wet years, and suffer from too little discharge on excessively dry years.

Restoration goals in the Caloosahatchee estuary include; re-establishment of a salinity range favorable to juvenile marine fish, shellfish, oysters and submerged aquatic vegetation (SAV), re-establishment of seasonally appropriate freshwater flows of favorable quality that maintain low salinities in the upper estuary and re-establishment of more stable salinities and ranges in the lower estuary. Restoration goals for the St. Lucie estuary include maintaining a salinity range favorable to fish, benthic invertebrates, oysters and SAV. This requires a reduction of high volume, long duration discharge events from Lake Okeechobee, the C-44, C-23 and C-24 watersheds.

In summary, CEPP may improve conditions for estuarine and marine resources throughout the Northern Estuaries by restoring more natural timing, volume, and duration of freshwater flows to the Caloosahatchee and St. Lucie estuaries. It has the potential to reduce excess nutrient loading and provide a more appropriate range of salinity conditions by reducing extreme salinity fluctuations and durations. The improvement of estuarine conditions will ultimately have a significant beneficial effect to essential fish habitat resources.

C.2.2.7 Hydrology

Hydrologic modeling simulations of the ECB and the FWO were developed with the RSM-BN and RSM-GL sub-regional modeling tools, to provide baseline conditions for plan formulation, the assessment of

CEPP project benefits (comparisons against FWO), and the assessment of CEPP alternative performance for the level-of-service for flood protection and water supply (comparisons against ECB). The ECB was developed to represent the system-wide infrastructure and operations that were in place at the time CEPP plan formulation was initiated, approximately January 2012. The FWO for CEPP assumes the construction and implementation of currently authorized CERP and non-CERP projects, and other Federal, state or local projects constructed or approved under existing governmental authorities that occur in the CEPP study area. Selection of the recommended plan is conducted based on comparisons between the CEPP alternatives and the CEPP FWO. The reader should refer to Section 2 of the CEPP PIR main report and Appendix C.1 for additional documentation of the ECB and FWO conditions.

The portion of the Greater Everglades within the CEPP project area includes WCA 1, WCA 2A, WCA 2B, WCA 3A, WCA 3B, and ENP. This overview of CEPP hydrological conditions is intended to provide a general overview of regional hydrological changes for Alt 4R and the CEPP recommended plan (Alternative 4R2) compared to the CEPP FWO. RSM-BN and RSM-GL hydrologic modeling simulations for the CEPP final array of alternatives were developed starting from the FWO modeling simulation. Since all of the components north of the red line were the same for the initial CEPP final array of alternatives (Alts 1 through 4), a single RSM-BN simulation was originally completed for all of the CEPP components north of the red line. However, during the modeling effort for the Alt 4R and Alt 4R2, revised RSM-BN simulations were completed for these alternative simulations to address performance shortfalls observed with Alt 4 and Alt 4M, including to avoid potential impacts to water supply levels of service in the Lake Okeechobee Service Area (LOSA) and the Lower East Coast (LEC) and to avoid increases in the number of low flow events to the St. Lucie Estuary. The revised RSM-BN simulations resulted in updated boundary conditions for the RSM-GL modeling of Alt 4R and Alt 4R2. Hydrologic performance within any specific spatial area is due to the combined effect of Alt 4R and Alt 4R2 components and operations identified throughout the project area. Deduction of cause-effect relationships between CEPP alternative components were conducted throughout the CEPP preliminary screening and alternative formulation effort (refer to **Sections 3** and **4** of the CEPP PIR/EIS main report). For a more detailed assessment, the reader should refer to the complete suite of RSM-GL modeling results. A map of the RSM-GL gage locations is provided in **Figure C.2.2-51**.

The ECB and FWO baseline condition assumptions, which were established early during the CEPP preliminary screening process (prior to February 2012), were not modified during the CEPP formulation process in order to maintain a consistent set of base conditions for screening and alternative evaluation purposes. Following identification of the recommended plan in June 2013, the base condition assumptions were subsequently revisited and updated to represent the most current information for the analysis of Savings Clause requirements and Project-Specific Assurances in Annex B. The revised 2012 Existing Condition Baseline (2012EC) updated the ECB to include implementation of ERTP operations for WCA-3A and the South Dade Conveyance system, in addition to minor localized corrections to improve RSM-GL representation of the S-9/S-9A operations and the L-28 weir (all other ECB assumptions remain unchanged; the complete assumptions tables for the ECB and 2012EC are provided in Annex A-2 of Appendix A). The revised Initial Operating Regime Baseline (IORBL1) updated the FWO to include final SFWMD proposed operational intent for the Restoration Strategies project, the 2.6 mile western Tamiami Trail bridge proposed with the initial increment of the DOI Tamiami Trail Next Steps Project (based on best available phased implementation information from DOI), operational updates to the CERP Indian River Lagoon South (IRLS) project (based on best available information from the IRLS project team), and operational refinements to the CERP Broward County Water Preserve Area project (to reduce excess discharges to tide via S-29, including accounting for the effects of the Lake Belt expansion assumed in the CEPP FWO condition), in addition to the same minor localized corrections

included with the 2012EC to improve RSM-GL representation of the S-9/S-9A operations and the L-28 weir (all other FWO assumptions remain unchanged; the complete assumptions tables for the FWO and IORBL1 are provided in Annex A-2 of Appendix A). Compared to the FWO baseline, the updated IORBL1 baseline indicates significant hydrologic differences with respect to the Saint Lucie Estuary, the L-28 Triangle, and Biscayne Bay, with other portions of the CEPP project area performing similar to the FWO; since the analysis contained in Annex B compares the recommended plan (ALT 4R2) to the IORBL1, a summary of these performance differences between the FWO and IORBL1 is provided in this section for the St. Lucie Estuary, the L-28 Triangle, and Biscayne Bay.

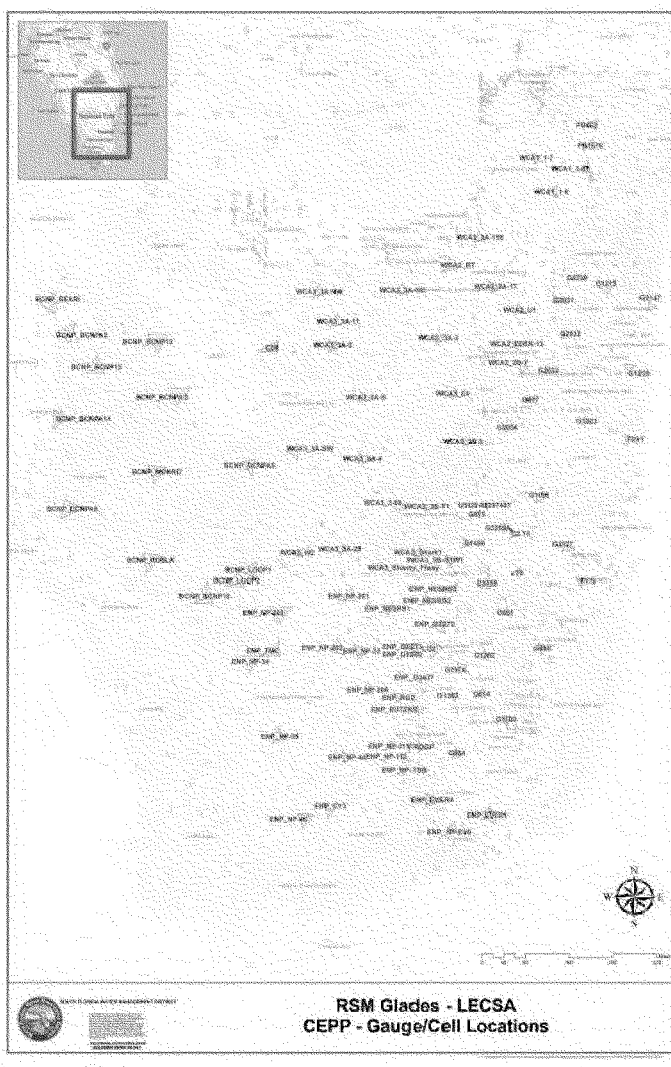


Figure C.2.2-51. Map of RSM-GL monitoring gage locations.

C.2.2.7.1 Lake Okeechobee and the Northern Estuaries

As a result of the CEPP preliminary screening process, operational changes were incorporated into the hydrologic modeling conducted for the CEPP alternatives, including the Alt 4R and the recommended plan Alt 4R2, in efforts to optimize CEPP system-wide performance within the assumed existing flexibility of the 2008 LORS. More specifically, the hydrologic modeling of the CEPP alternatives included proposed revisions to the 2008 LORS decision tree outcome maximum allowable discharges dependant on the following criteria: Lake Okeechobee inflow and climate forecasts (class limits were modified for tributary hydrologic conditions, seasonal climate outlook, and multi-seasonal climate outlook), stage level (regulation zone), and stage trends (receding or ascending). While some refinements were made within the operational flexibility available in the 2008 LORS, consistent with the original modeling intent, the final operational assumptions ultimately extended beyond this flexibility due to adjustments made to the tributary/climatological classifications. Minor modifications to the operational assumptions were included for Alt 4R and Alt 4R2, compared to Alts 1 through 4. For all CEPP alternatives, the LORS 2008 Regulation Schedule zones were unchanged. Additional information and documentation of these assumptions can be found in the Engineering Appendix of the CEPP PIR.

Compared to the FWO, Alt 4R2 Lake Okeechobee stages are increased by 0.25-0.50 feet for the upper 70% of the stage duration curve, excluding extreme wet hydrologic conditions (**Figure C.2.2-52**). Compared to the FWO, Alt 4R Lake Okeechobee stages are increased by 0.25-0.50 feet for the upper 60% of the stage duration curve, excluding extreme wet hydrologic conditions. Compared to Alt 4, Lake Okeechobee stages for Alt 4R and Alt 4R2 are slightly increased by less than 0.10 feet during the upper 40% of the stage duration curve. Peak lake stage increased from 17.50 feet NGVD in the FWO to 17.64 feet NGVD in Alt 4R and 17.66 feet NGVD for Alt 4R2. The number of days with stages above 16 feet NGVD is increased from 696 in the FWO to 1157 and 1162 in Alt 4R and Alt 4R2, respectively, during the 1965-2005 period of simulation. Average annual total discharges from Lake Okeechobee to the Northern Estuaries were reduced from 621 kAF in the FWO (435 to the Caloosahatchee Estuary; 186 to the St. Lucie Estuary) to 493 kAF in Alt 4R (350 to the Caloosahatchee Estuary; 143 to the St. Lucie Estuary) and 482 kAF in Alt 4R2 (356 to the Caloosahatchee Estuary; 126 to the St. Lucie Estuary).

For the Caloosahatchee Estuary, compared to the FWO, mean monthly flows above 2800 cfs and 4500 cfs are reduced by 11 months and 4 months, respectively for Alt 4R2 (14% and 12% reductions, respectively; **Figure C.2.2-53**). Mean monthly flows above 2800 cfs and 4500 cfs are reduced by 11 and 3 months, respectively for Alt 4R (14% and 9% reductions, respectively. Mean monthly flows less than 450 cfs are reduced by 4 months (15%) for Alt 4R2 and 3 months (11%) for Alt 4R (**Figure C.2.2-54**).

For the St. Lucie Estuary, compared to the FWO, mean monthly flows above 2000 cfs and 3000 cfs are reduced by 29 months and 7 months, respectively for Alt 4R2 (34% and 23% reductions, respectively; **Figure C.2.2-55**). Mean monthly flows above 2000 cfs and 3000 cfs are reduced by 27 months and 5 months, respectively for Alt 4R (32% and 16% reductions, respectively. Mean monthly flows less than 350 cfs are decreased by 27 months (29%) for Alt 4R2 and decreased by 2 months (2%) for Alt 4R (**Figure C.2.2-56**).

For the St. Lucie Estuary, compared to the IORBL1, mean monthly flows above 2000 cfs and 3000 cfs are reduced by 15 months and 5 months, respectively for Alt 4R2 (21% and 17% reductions, respectively). Compared to the IORBL1, mean monthly flows less than 350 cfs are increased by 12 months (23%) for Alt 4R2. Average annual total discharges from Lake Okeechobee to the Northern Estuaries were reduced

from 625 kAF in the IORBL1 (441 to the Caloosahatchee Estuary; 184 to the St. Lucie Estuary) to 482 kAF in Alt 4R2 (356 to the Caloosahatchee Estuary; 126 to the St. Lucie Estuary).

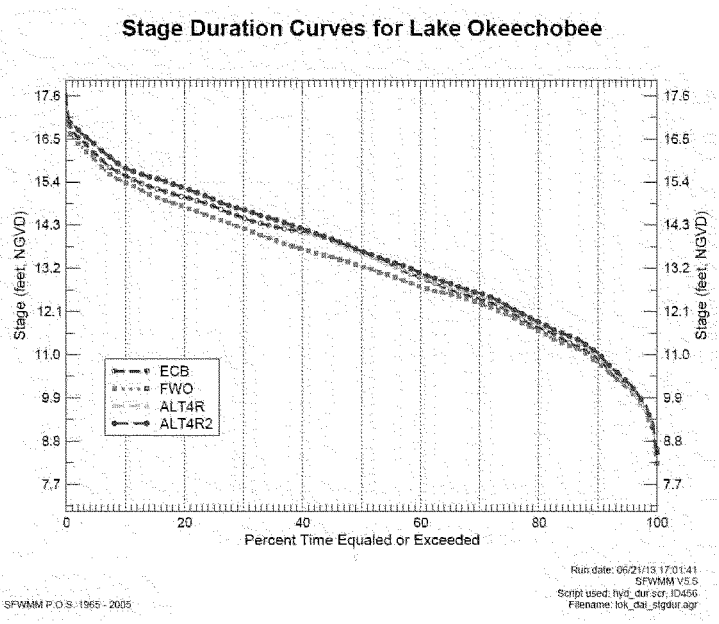


Figure C.2.2-52. Lake Okeechobee Stage Duration Curve for CEPP Alt 4R and Alt 4R2.

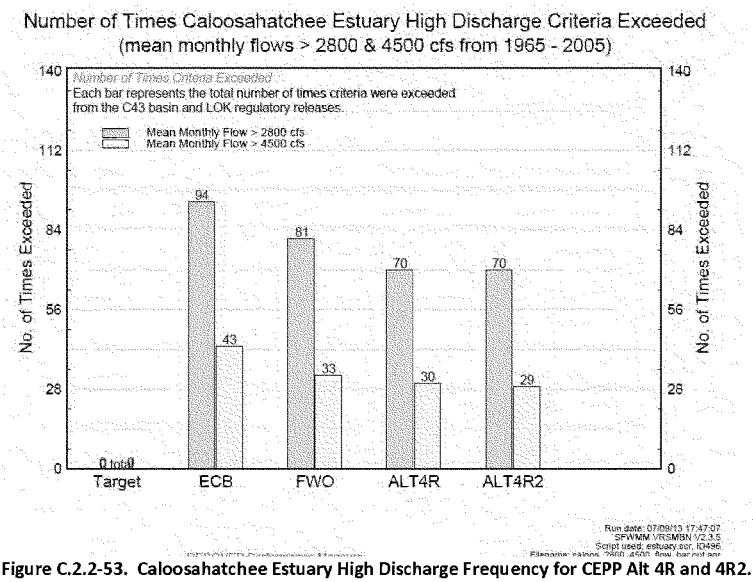


Figure C.2.2-53. Caloosahatchee Estuary High Discharge Frequency for CEPP Alt 4R and 4R2.

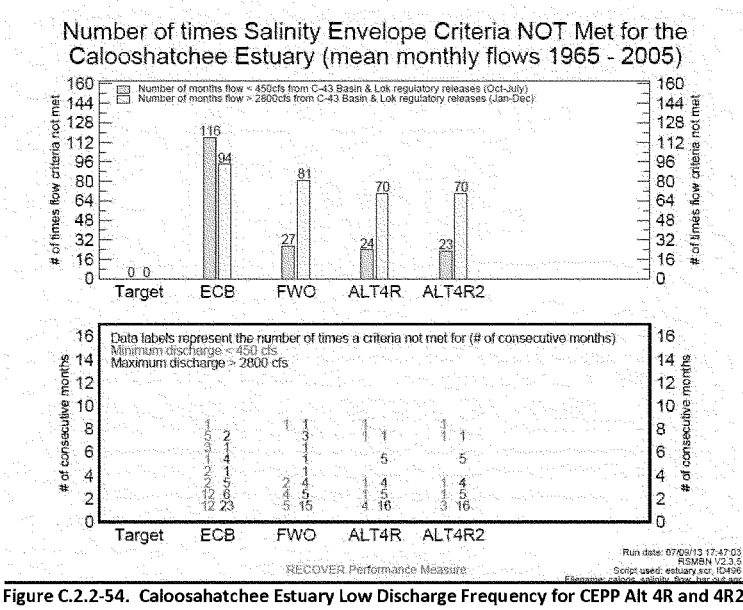


Figure C.2.2-54. Caloosahatchee Estuary Low Discharge Frequency for CEPP Alt 4R and 4R2.

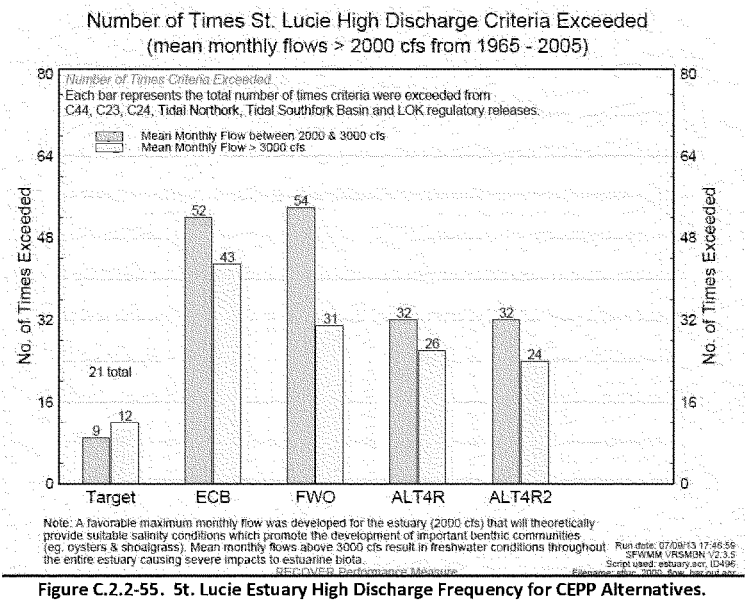


Figure C.2.2-55. St. Lucie Estuary High Discharge Frequency for CEPP Alternatives.

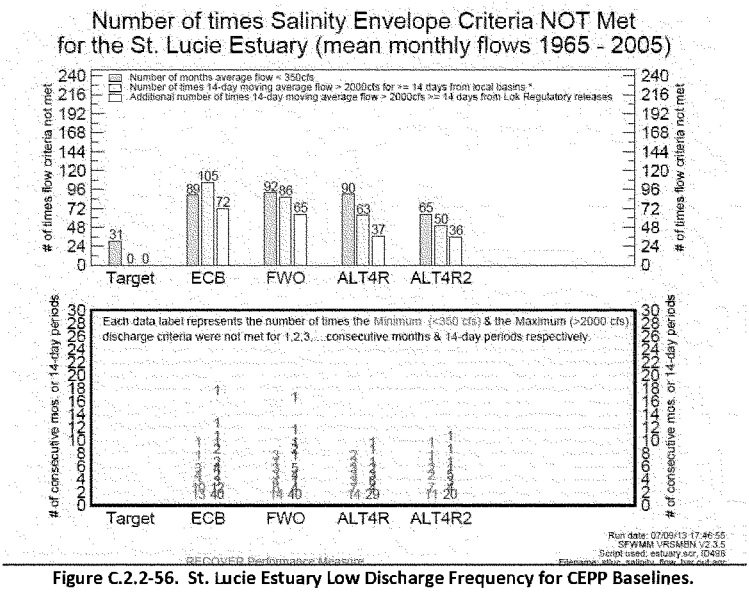


Figure C.2.2-56. St. Lucie Estuary Low Discharge Frequency for CEPP Baselines.

C.2.2.7.2 Everglades Agricultural Area

Minor changes to groundwater levels are expected adjacent to the proposed CEPP A-2 FEB (14,000 acres), compared to the FWO which includes the SFWMD Restoration Strategies A-1 FEB. The A-2 FEB design includes perimeter seepage collection canals and associated seepage pumps to limit potential impacts. Detailed CEPP assessments within the EAA are not available because the RSM-BN does not simulate groundwater within the EAA.

C.2.2.7.3 Water Conservation Area 1

Compared to the FWO, no significant changes to WCA 1 stages are indicated with Alt 4R or Alt 4R2. Average annual regulatory releases from WCA 1 to WCA 2A via the S10 structures are slightly reduced from 268,000 acre-feet (268 kAF) to approximately 266 kAF with Alt 4R and Alt 4R2.

C.2.2.7.4 Water Conservation Area 2A and 2B

Compared to the FWO, WCA 2A stages are moderately decreased by 0.1-0.3 feet under all hydrologic conditions for Alt 4R and Alt 4R2 (**Figure C.2.2-57**). Average annual inflows from STA 2 (including Compartment B) to WCA 2A are significantly decreased from 381 kAF to 230 kAF in Alt 4R (a 40% decrease) and 236 kAF in Alt 4R2 (a 38% decrease) with the assumed implementation of the L-6 diversion from WCA 2A to WCA 3A. The S-7 pump station also contributes inflows to WCA 2A; S-7 inflows are reduced from 77 kAF in the FWO to 29 kAF in Alt 4R and 68 kAF in Alt 4R2, due to operations to redirect a portion of STA-3/4 discharges away from WCA 2A to WCA 3A via the S-8 pump station. The L-6 diversion from WCA 2A to WCA 3A is utilized approximately 70 percent of the period of simulation under the recommended plan Alt 4R2 operations (reduced compared to Alt 4R), with the maximum diversion capacity of 500 cfs approximately 17 percent of the period of simulation. Average annual regulatory releases from WCA 2A to WCA 3A via the S11s are significantly decreased from 460 kAF in the FWO to 290 kAF for Alt 4R and 323 kAF for Alt 4R2.

Compared to the FWO, Alt 4R stages within WCA 2B are significantly decreased by 0.25-0.50 feet under nearly all hydrologic conditions, excluding extreme wet conditions, for Alt 4R (**Figure C.2.2-58**). Stages are approximately equivalent to the ECB. Alt 4R2 operational adjustments to reduce the frequency and magnitude of the L-6 diversion operations resulted in increased stages within WCA 2B. Compared to the FWO, Alt 4R2 stages within WCA 2B are slightly decreased by less than 0.10 feet between the 20^{th} and 60^{th} percentiles of the stage duration curve and stages are decreased by 0.25 feet during the driest 20 percent of the stage duration curve. Changes within WCA 2B are directly related to the decreased stages within WCA 2A and decreased inflows from S-144, S-145, S-146, and seepage.

C.2.2.7.5 L-28 Triangle and Western L-28 Basin

Located to the west of northwestern WCA 3A, the areas immediately west of the L-28 Levee are affected by the increased stage levels in northwest WCA 3A through increased seepage westward across the L-28 Levee. South of the L-4 Levee and north of Interstate 75 (approximately 11 miles), the areas immediately west of the L-28 Levee include the Seminole Tribe of Florida's Big Cypress Reservation and the Miccosukee Tribe of Indians of Florida's Reservation. Compared to the FWO, Alt 4R and Alt 4R2 stages immediately west of the L-28 Levee are increased by 0.1-0.2 feet under wet to normal hydrologic conditions and increased by 0.2-0.3 feet under normal to dry hydrologic conditions, with no significant change indicated for extreme wet or dry conditions (**Figure C.2.2-59**). Stage increases are only observed for the RSM-GL cells located immediately west of the L-28 Levee, which correspond to approximately 1-2 miles west of L-28. Average annual hydroperiods for these cells are increased by 10 to 60 days with Alt 4R and Alt 4R2 for the 7-8 miles north of Interstate 75 (FWO hydroperiods range from 25-150 days), with no

significant hydroperiod changed indicated for the 2-3 miles south of L-4 (FWO hydroperiods range from 0-15 days) .

The L-28 Triangle area is located entirely within the boundaries of the Miccosukee Tribe of Indians of Florida's Reservation and encompasses 7830 acres of Tribal lands and approximately 230 acres of BCNP. The L-28 Triangle area is confined on north by Interstate 75, the west by L-28 Interceptor Canal (L-28I) and the BCNP, and the east by the L-28 Canal. Although Alt 4R and Alt 4R2 do not include modifications to the L-28 Levee or the adjacent canal, stages within the L-28 Triangle are significantly increased by 0.25-1.0 feet during normal to extreme wet hydrologic conditions, compared to the FWO. This anomalous stage increase is the result of a localized correction to improve RSM-GL representation of the L-28 weir, which was implemented for the updated ECB (2012EC) and the updated FWO (IORBL1), and retained (unchanged compared to the IORBL1) in Alt 4R and Alt 4R2. The ECB and FWO baseline conditions should not be compared to the Alt 4R and Alt 4R2 results. Alt 4R and Alt 4R2 results for the L-28 Triangle area can only be meaningfully compared to the 2012EC and IORBL1.

Although Alt 4R and Alt 4R2 do not include modifications to the L-28 Levee or the adjacent canal, stages within the L-28 Triangle are slightly increased by 0.1-0.2 feet during nearly all hydrologic conditions, due to groundwater interactions with the down-gradient western WCA 3A marsh (**Figure C.2.2-60**). Compared to the FWO, no stage increases are indicated during extreme wet hydrologic conditions.

C.2.2.7.6 Big Cypress National Preserve

Stages within the BCNP, west of WCA 3A and Western Shark River Slough (ENP), do not change significantly between the CEPP FWO, Alt 4R, and Alt 4R2.

C.2.2.7.7 Water Conservation Area 3A and 3B

The hydrologic effects of the CEPP alternatives include the combined effects from implementation of the A-2 FEB, the L-6 Diversion, the northern WCA 3A hydropattern restoration components along L-4, the Miami Canal backfill (north of Interstate 75), and the proposed new or expanded WCA 3A outlet structures along L-67A, along with the associated operations. Compared to the FWO, average annual combined structural inflows to WCA 3A from STA 3/4, STA 5/STA 6 (including Compartment C), and WCA 2A are significantly increased from 1,028 kAF to 1,258 kAF (a 22% increase) with Alt 4R2. Compared to the FWO, average annual combined structural inflows to WCA 3A from STA 3/4, STA 5/STA 6 (including Compartment C), and WCA 2A are significantly increased from 1,028 kAF to 1,266 kAF (a 23% increase) with Alt 4R. In order to avoid adverse increases to the frequency, duration, and peak stages of WCA 3A high water conditions with this net increase in WCA 3A inflows, average annual combined structural outflows from WCA 3A through S-151 (to WCA 3B), three new outflow structures along L-67A (to WCA 3B), S-333 (to ENP NESRS), the S-12 structures (to ENP WSRS), and the S343/S344 culverts are also significantly increased from 1,190 kAF in the FWO to 1,427 kAF in Alt 4R2 and 1,423 kAF in Alt 4R (approximately 20% increases).

Since WCA 3A covers approximately 752 square miles, hydrologic differences between the CEPP FWO , Alt 4R, and Alt 4R2 are characterized at representative gages throughout WCA 3A.

Within northwest WCA 3A, compared to the FWO, stages are generally significantly increased by 0.6-0.8 feet for Alt 4R and Alt 4R2 (**Figure C.2.2-61**). Stages within northeast WCA 3A are generally significantly increased by 0.4-0.7 feet for Alt 4R and Alt 4R2, with no significant change during extreme wet conditions and a slight increase in stage for extreme dry conditions (**Figure C.2.2-62**); Alt 4R2 stages are slightly reduced, by less than 0.10 feet, compared to Alt 4R2 due to the reduced frequency and

magnitude of L-6 diversion operations. Within east-central WCA 3A (3A-3), Alt 4R and Alt 4R2 stages are generally significantly increased by 0.2-0.5 feet, with no significant change during the wettest 20% of conditions (**Figure C.2.2-63**). Proceeding south within central WCA 3A (3A-4), Alt 4R and Alt 4R2 stages are generally increased by 0.1-0.2 feet during average to dry conditions, with a slight depth reduction during the wettest 10% of conditions and no significant change during extreme dry conditions (**Figure C.2.2-64**). Southern WCA 3A (3A-28) stages for Alt 4R and Alt 4R2 are decreased by 0.1-0.2 feet during the wettest 5% of conditions and slightly decreased during normal to dry conditions (**Figure C.2.2-65**).

The CEPP FWO includes the existing S-151 gated culvert as the sole structural inflow to WCA 3B (327 kAF average annual) and the existing S-355 A and B spillways as the only structural outflows from WCA 3B (<2 kAF average annual). Alt 4R and Alt 4R2 include three new inflow structures to WCA 3B along L-67A (in addition to increased capacity at S-333), resulting in an additional WCA 3B inflow design capacity of 1500 cfs. Compared to the FWO, average annual combined structural inflows to WCA 3B from WCA 3A are significantly increased from 327 kAF in the FWO to 544 in Alt 4R2 and 548 in Alt 4R (66-67 percent increase). The WCA 3B outflow configuration for Alt 4R and Alt 4R2 includes the removal of the L-29 Levee within the Blue Shanty flowway. Water budget maps with surface water flow vectors for Alt 4R and Alt 4R2, focusing primarily on the structure flows (kAF average annual) and locations (levee seepage flux along L-30 and L-29 is also indicated), are provided in **Figure C.2.2-66** and **Figure C.2.2-67**, similar to the graphics previously provided for Alts 1 through 4; the WCA 3B inflow structures indicated for the Alt 4R2 hydrologic modeling (S-345D, S-345F, and S-345G) were renamed to S-631, S-632, and S-633 (sequenced from north to south) following identification of Alt 4R2 as the CEPP recommended plan. Alt 4R and Alt 4R2, with the Blue Shanty flowway and L-29 Levee Gap, achieve significant north-to-south surface water flow directionality within WCA 3B only in the spatial footprint of the Blue Shanty flowway. Compared to the FWO, average annual combined structural outflows from WCA 3B to the L-29 Canal and ENP NESRS are significantly increased from less than 2 kAF in the FWO to 240 kAF in Alt 4R2 and 238 kAF in Alt 4R, with more than 99 percent of these WCA 3B outflows in Alt 4R2 and Alt 4R discharged across the L-29 Levee degrade within the Blue Shanty flowway. Also included in the WCA 3B water budget, average annual combined structural outflows from WCA 3B to the Lower East Coast (S-31 and S-337) are moderately reduced from 128 kAF in the FWO to 104 kAF in Alt 4R2 and 107 kAF in Alt 4R. Peak stages within central WCA 3B (Site 71) exceed 9.0 feet NGVD for only 15 days (0.10%) of the RSM-GL 1965-2005 period of simulation for both alternatives (compared to 9 days for Alt 4), and WCA 3B stages are above 8.0 feet NGVD for approximately 22-24% or the period of simulation (compared to 21% for Alt 4); Alt 4R2 stages at Site 71 are slightly higher than Alt 4R.

The WCA 3B hydrologic effects, resultant from the targeted increased inflows to eastern WCA 3B with Alt 4R and Alt 4R2, compared to Alt 4, are apparent. Compared to the FWO, Alt 4R and Alt 4R2 stages at WCA 3B Site 71 are increased under all hydrologic conditions (**Figure C.2.2-68**), including stage increases of 0.1 feet during the upper 20% of the stage duration curve (wet to extreme wet conditions), stage increases of 0.2-0.3 feet for normal to dry conditions, and a slight stage increase during extreme dry conditions. Resultant from the CEPP plan formulation process, based on ecological, seepage management, and cost considerations, stages within eastern WCA 3B for Alt 4R and Alt 4R2 were intentionally managed lower than within the Blue Shanty flowway, and increased structural inflows to this area of WCA 3B (S-345D) were targeted to achieve benefits of an extended hydroperiod without significantly increasing WCA-3B discharges through the existing S-355A and S-355 gravity spillway structures. For Alt 4R and Alt 4R2, the stage duration curves for stages within the interior of the Blue Shanty flowway and the down-gradient L-29 Canal stages are shown in **Figure C.2.2-69** and **Figure C.2.2-70**. For Alt 4R2, the peak stage within the Blue Shanty flowway is 9.70 feet NGVD and stages exceed 8.0 feet NGVD for approximately 42% of the period of simulation. For Alt 4R, the peak stage

within the Blue Shanty flowway is 9.74 feet NGVD and stages exceed 8.0 feet NGVD for approximately 45% of the period of simulation. The Alt 4R2 simulation included operational constraints for the inflow structures to the Blue Shanty flowway (S-345F and S-345G) to prevent L-29 Canal stages from exceeding 9.7 feet NGVD, the assumed design high water criteria for the DOI TTNS project. Within the Blue Shanty Flowway, approximately 97 percent of the increase in average annual structural inflows to this area of WCA 3B are discharged across the L-29 Levee degrade.

C.2.2.7.8 Northeast Shark River Slough

Consistent with Alts 1 through 4, Alt 4R and Alt 4R2 assumes the L-29 Canal maximum operational limit at 9.7 feet NGVD (7.5 feet NGVD is used for the ECB and FWO) and removal of the G-3273 stage constraint (6.8 feet NGVD is used for the ECB and FWO). Total net structural inflows to NESRS (via the L-29 Canal), computed as the sum of S-333, S355A, S-355B, L29 Levee Gap, and S-356 minus S-334), are significantly increased to 761 kAF with Alt 4R and Alt 4R2, compared to the CEPP FWO (94 kAF average annual); L-29 inflows are slightly increased compared to Alt 4 (717 kAF).

Stage duration curves for the L-29 Canal are provided in **Figure C.2.2-71** and **Figure C.2.2-72** (upper 25% only) (note: for Alt 4R and Alt 4R2, L-29 Canal stages are indicated west of the proposed L-29 divide structure). For Alt 4R and Alt 4R2, peak stages in the L-29 Canal range are 9.59-9.60 feet NGVD west of the L-29 divide structure and 9.50-9.51 feet NGVD east of the L-29 divide structure (the FWO peak stage is 8.43 feet NGVD). Based on the assumed operational constraints, the CEPP FWO L-29 Canal stage exceeds the maximum operational limit of 7.5 feet NGVD approximately 6% of the 1965-2005 RSM-GL period of simulation (due to direct rainfall); by contrast, the 9.7 feet NGVD maximum operational limit prescribed for Alt 4R and Alt 4R2 is not constraining during any period within the period of simulation, and L-29 Canal stages exceed 8.5 feet NGVD during only approximately 11% of the period of simulation within the western L-29 Canal and approximately 5% within the eastern L-29 Canal segment in both alternatives.

Compared to the FWO, stages are significantly increased by 0.5-0.9 feet under all hydrologic conditions at NESRS-2 for Alts 4R and Alt 4R2 (**Figure C.2.2-73**). Similar trends are also observed further south at the NESRS-1 monitoring gage. Changes to the average annual overland flow to NESRS across RSM-GL transect 18 are shown in **Figure C.2.2-75**; a reference map for the RSM-GL transects (which are consistent with the SFWMM model transects, adjusted for the RSM grid resolution) is provided in **Figure C.2.2-74**.

C.2.2.7.9 Western Shark River Slough

WSRS, located to the west of L-67 Extension Levee and bounded on the north by Tamiami Trail, is primarily influenced by rainfall and water management operations at the S-12 structures (A, B, C and D). Under ERTP, the utilization of the S-12 structures and the seasonal sequential closure periods beginning from the west at S-12A (November 1 – July 14) and S-12B (January 1 – July 14), respectively, is meant to move water from WCA 3A into SRS while providing conditions for Cape Sable seaside sparrow Subpopulation-A (CSSS-A) nesting and breeding. Modification to the ERTP seasonal closure periods for the S-12A and S-12B was not considered during CEPP preliminary screening and alternative formulation, based on USACE consideration of the USFWS Biological Opinion for ERTP.

Changes to the average annual overland flows to WSRS across RSM-GL transect 17 are shown in **Figure C.2.2-76**. Compared to the FWO, Alt 4R and Alt 4R2 stages within northwest ENP (NP-201) are generally significantly decreased by 0.1-0.3 feet under both wet and dry hydrologic conditions; stages are slightly increased or unchanged from the FWO for normal hydrologic conditions between approximately 35%

and 55% on the stage duration curve (**Figure C.2.2-77**). To the south and west, the NP-205 monitoring gage (used as an indicator for CSSS-A hydrology) indicates a potentially significant stage decrease of 0.1-0.2 feet under all hydrologic conditions for all alternatives, including Alt 4R and Alt 4R2, compared to the FWO (**Figure C.2.2-78**). Stages further south within Central Shark River Slough (P-33) are generally significantly increases by 0.2-0.4 feet under all hydrologic conditions for Alt 4R and Alt 4R2 (**Figure C.2.2-79**). Stages within Central Shark River Slough demonstrate a combined hydrologic response to the hydrologic changes previously indicated for both NESRS and WSRS; the resultant combined average annual transect flows within Central Shark River Slough (Transect 27) are significantly increased from an average annual volume of 594 kAF with the FWO to 758 kAF for Alt 4R (28% increase) and 760 kAF for Alt 4R2 (28% increase) (**Figure C.2.2-80**).

C.2.2.7.10 Taylor Slough

Compared to the FWO, ENP stages along Taylor Slough (NP-TSB) are slightly decreased by approximately 0.1 feet during the wettest 20% of hydrologic conditions and slightly increased by 0.1-0.2 feet during normal to dry hydrologic conditions with Alt 4R and Alt 4R2 (**Figure C.2.2-81**). Consistent with Alt 4, Alt 4R and Alt 4R2 each include the Blue Shanty flowway and the L-29 divide structure to direct surface water flows further west within NESRS, as compared to Alts 1 through 3.

C.2.2.7.11 Lower East Coast Area

The LEC area is located to the east of the L-31N, L-31W, and C-111 canals. Under the FWO (ERTP), specified canal water levels/ranges are meant to provide flood protection, water supply, and prevention of saltwater intrusion for the LEC. For the CEPP final array of alternatives, including Alt 4R and Alt 4R2, the operations for the SDCS are changed from the FWO operations for G-211 and the coastal canals are utilized to convey seepage water to Biscayne Bay to offset for reduced flows caused by implementation of CEPP.

Observed stage changes within the LEC are separately discussed with the summary of flood control and water supply performance for the CEPP alternatives, included in **Section C.2.2.8**.

C.2.2.7.12 8.5 Square Mile Area

Consistent with Alts 1 through 4, Alt 4R and Alt 4R2 modify the FWO operations of the S-357 pump station, in an effort to increase discharges from the 8.5 SMA detention cell to the C-111 South Dade North Detention Area and reduce the reliance on the S-331 pump station in L-31N to provide flood mitigation for the 8.5 SMA protected area. Details of the S-357 operations are provided with the documentation of the modeling assumptions for the CEPP action alternatives, located in Annex A-2 of the Engineering Appendix (Appendix A). The protected portion of the 8.5 SMA is represented by three model grid cells in the RSM-GL (**Figure C.2.2-82**), and the resolution of the RSM-GL is extremely limiting for adequate representation of the 8.5 SMA project features. Prior to implementation of CEPP, further technical investigations will likely be needed for the 8.5 SMA operations, and additional hydrologic/hydraulic modeling with a higher resolution model may be required.

The 8.5 SMA detention cell weirs were lowered with Alt 4R and Alt 4R2 to allow overflow when depths exceeded 1.0 feet, which resulted in performance improvements within the southwestern portion of the 8.5 SMA protected area compared to Alts 1 through 4. RSM-GL modeling of Alt 4R and Alt 4R2 indicate that stages within the 8.5 SMA are lowered by approximately 0.25-0.50 feet during wet conditions for the three RSM-GL grid cells 2965 that represent the protected portion of the 8.5 SMA, compared to the FWO. Stages for the southwest portion of the 8.5 SMA protected area are indicated in **Figure C.2.2-83**.

C.2.2.7.13 Biscayne Bay

Combined total average annual surface water canal discharges to central and southern Biscayne Bay (S-336, S-338, S-194, S-196, S-197) are reduced by approximately 9 kAF for Alts 4R, compared to the FWO. Average annual surface water canal discharges to northern Biscayne Bay (S-29, S-28, S-27), which are affected by the assumed operations of the CERP BCWPA project, are slightly reduced by 2 kAF for Alt 4R, compared to the FWO. Modifications to the Alt 4 L-31N seepage cutoff wall and SDCS operations were specifically targeted to limit potential water supply reductions to Biscayne Bay (canal discharges to the central and southern Biscayne Bay were reduced by 37 kAF, and canal discharges to northern Biscayne Bay were reduced by 7 kAF for Alt 4). In response to potential Savings Clause concerns with this reduction to Biscayne Bay, Alt 4R2 operations were further adjusted to direct a larger quantity of the CEPP increased seepage from WCA 3B and NESRS to Biscayne Bay. Combined total average annual surface water canal discharges to central and southern Biscayne Bay (S-336, S-338, S-194, S-196, S-197) are increased by approximately 17 kAF for Alt 4R2, compared to the FWO. Average annual surface water canal discharges to northern Biscayne Bay (S-29, S-28, S-27), which are affected by the assumed operations of the CERP BCWPA project, are reduced by 46 kAF for Alt 4R2, compared to the FWO.

Combined total average annual surface water canal discharges to central and southern Biscayne Bay (S-336, S-338, S-194, S-196, S-197) are increased by approximately 15 kAF for Alt 4R2, compared to the IORBL1. Average annual surface water canal discharges to northern Biscayne Bay (S-29, S-28, S-27), which are affected by the assumed operations of the CERP BCWPA project, are reduced by 4 kAF for Alt 4R2, compared to the IORBL1.

C.2.2.7.14 Florida Bay

For Alt 4R and Alt 4R2, average annual surface water transect flows from southeastern ENP towards Florida Bay are increased by 2 kAF (7%) for Craighead Basin (RSM-GL Transect 23-A), increased by 8-10 kAF (11-14%) from Taylor Slough (Transect 23-B), and increased by 13-15 kAF (9-10%) for the Eastern Panhandle of ENP (Transect 23-C), resulting in a net increase of approximately 27 kAF for Alt 4R and 23 kAF for Alt 4R2, compared to the FWO. Alt 4R2 overland flows to Florida Bay are slightly reduced compared to Alt 4R for Transect 23-B and Transect 23-C. The salinity effects within Florida Bay from this overall increase and changed spatial distribution of flows were also evaluated by the CEPP ecological sub-team (with additional RECOVER support), and additional information for the changes observed between Alt 4R and Alt 4R2 compared to the FWO is discussed in **Appendix G, Environmental Benefits Model**.

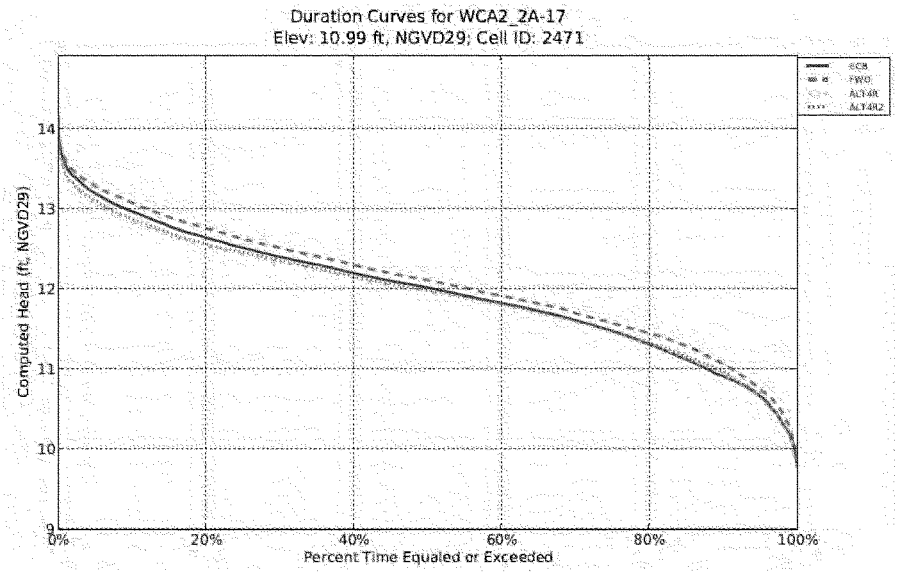


Figure C.2.2-57. Central WCA 2A Stage Duration Curve.

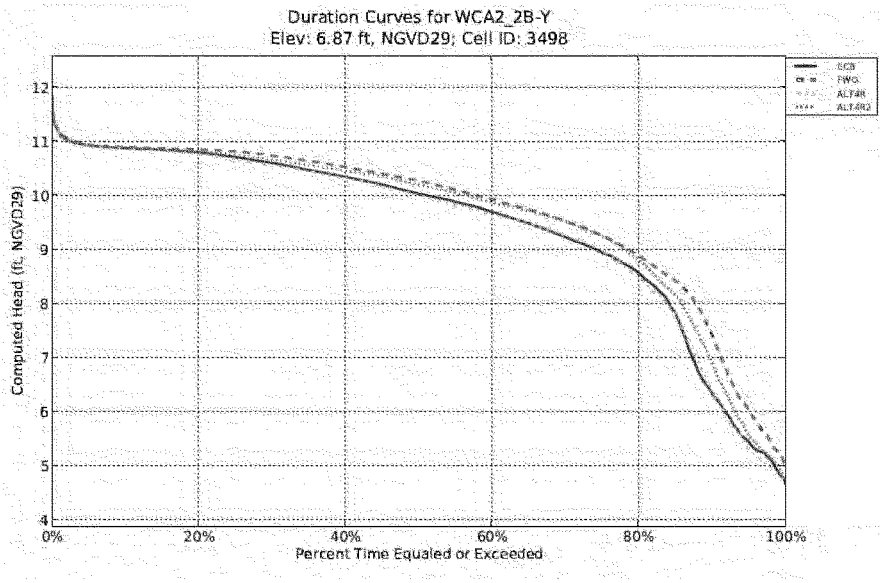


Figure C.2.2-58. Southern WCA 2B Stage Duration Curve.

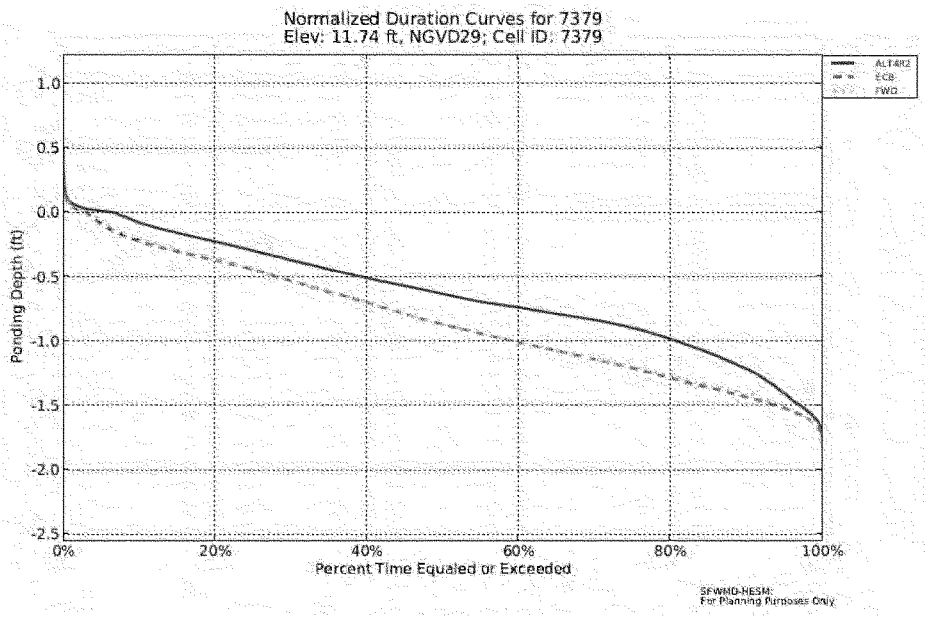


Figure C.2.2-59. Western L-28 Basin Stage Duration Curve.

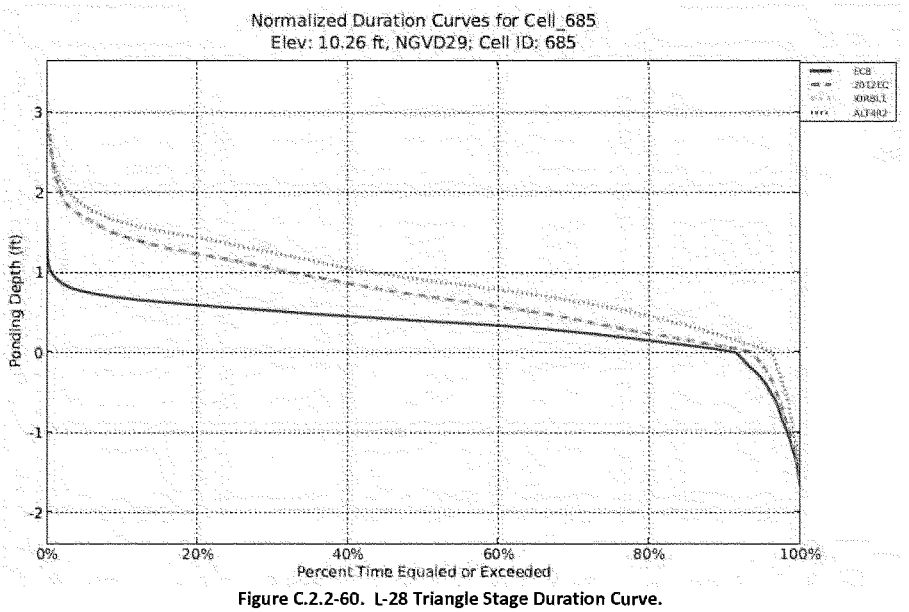


Figure C.2.2-60. L-28 Triangle Stage Duration Curve.

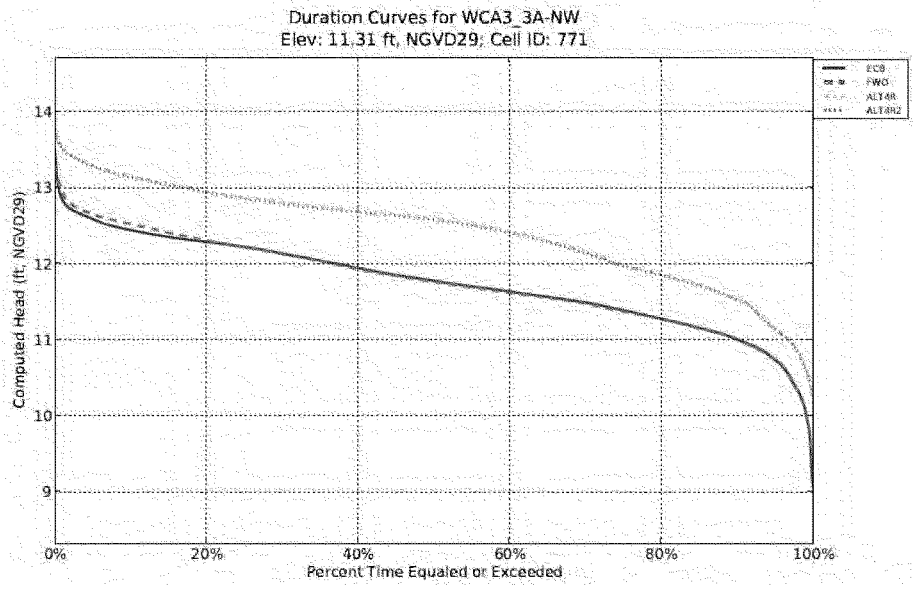


Figure C.2.2-61. Northwest WCA 3A Stage Duration Curve.

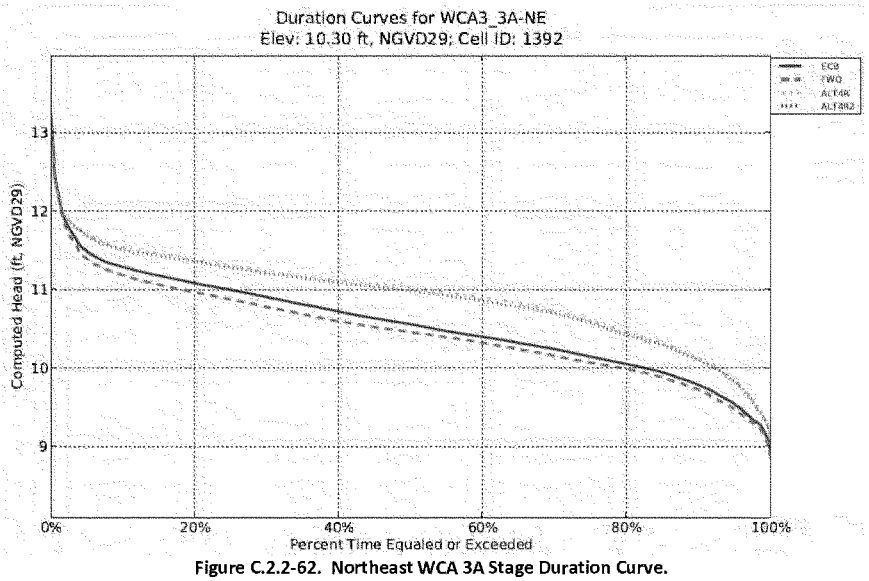


Figure C.2.2-62. Northeast WCA 3A Stage Duration Curve.

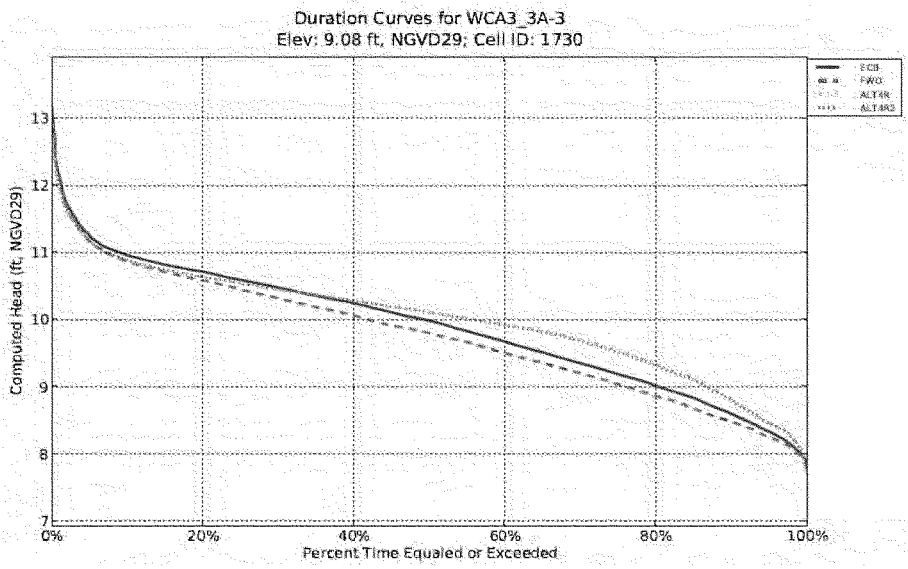


Figure C.2.2-63. East-Central WCA 3A Stage Duration Curve.

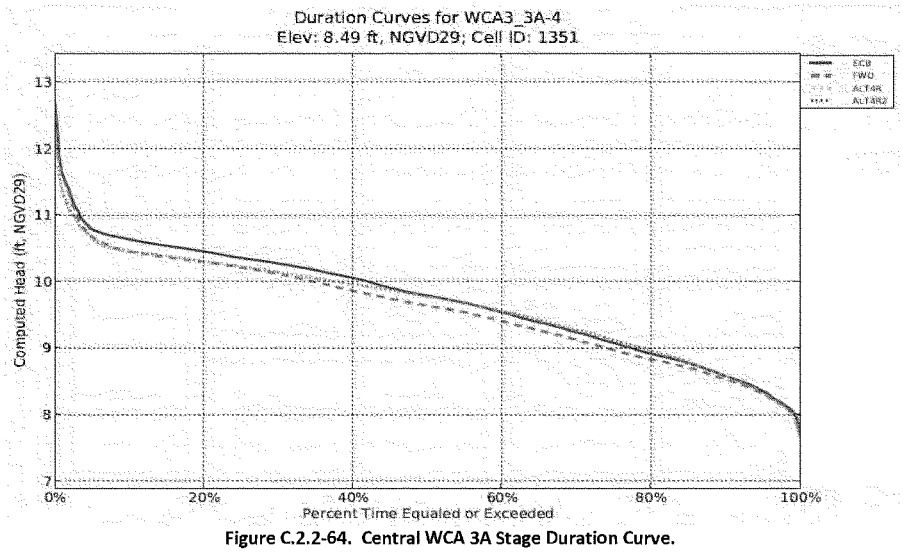


Figure C.2.2-64. Central WCA 3A Stage Duration Curve.

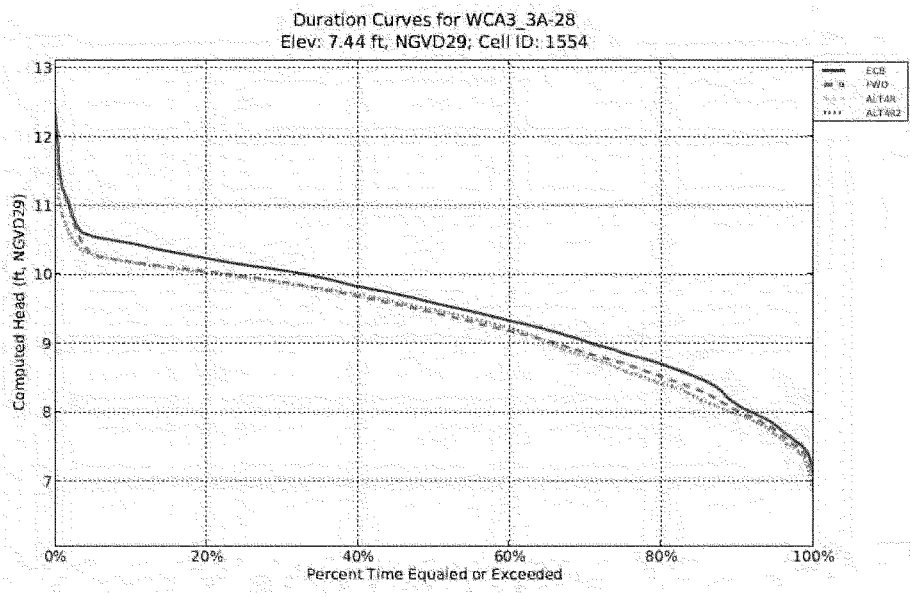


Figure C.2.2-65. South WCA 3A Stage Duration Curve

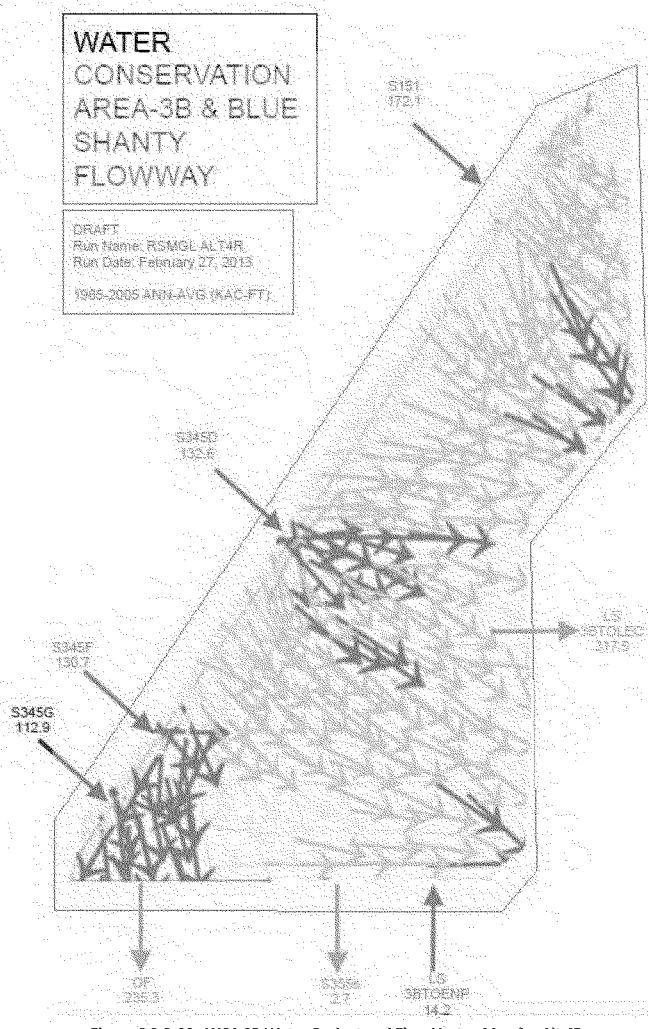


Figure C.2.2-66. WCA 3B Water Budget and Flow Vector Map for Alt 4R.

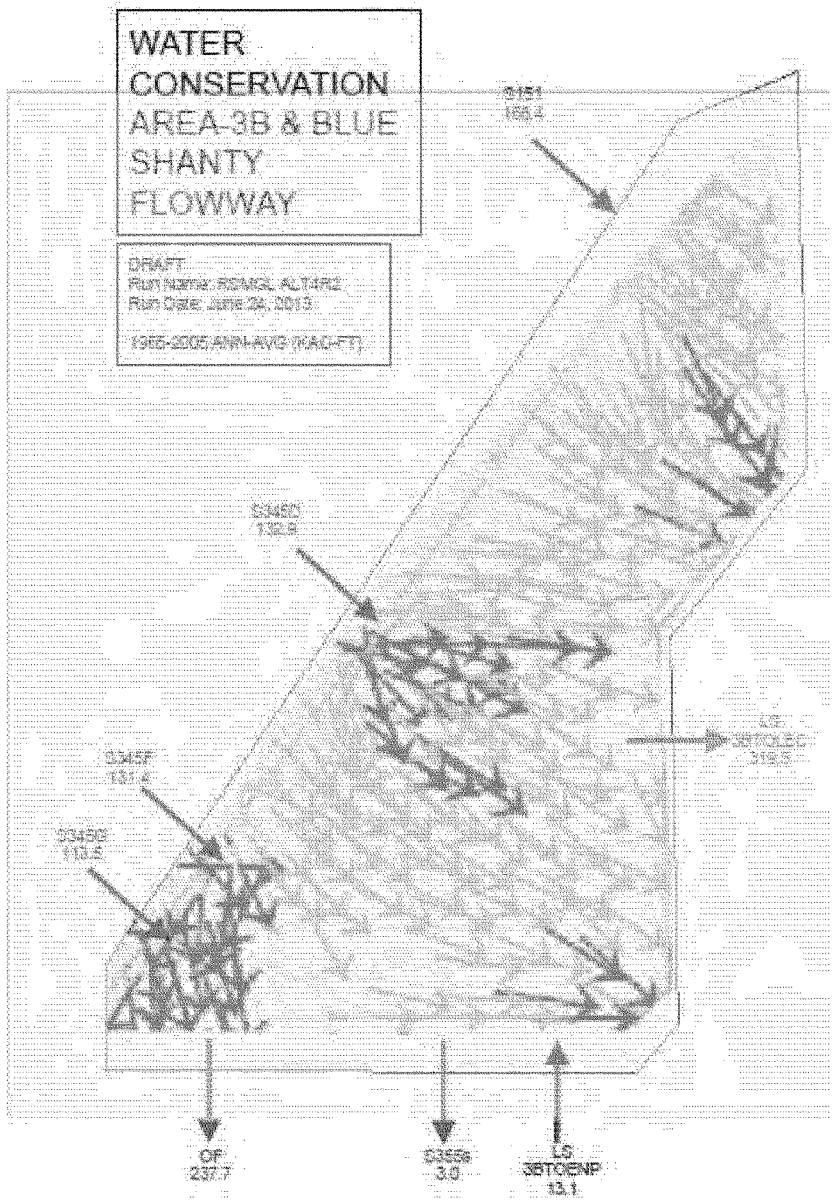


Figure C.2.2-67. WCA 3B Water Budget and Flow Vector Map for Alt 4R2

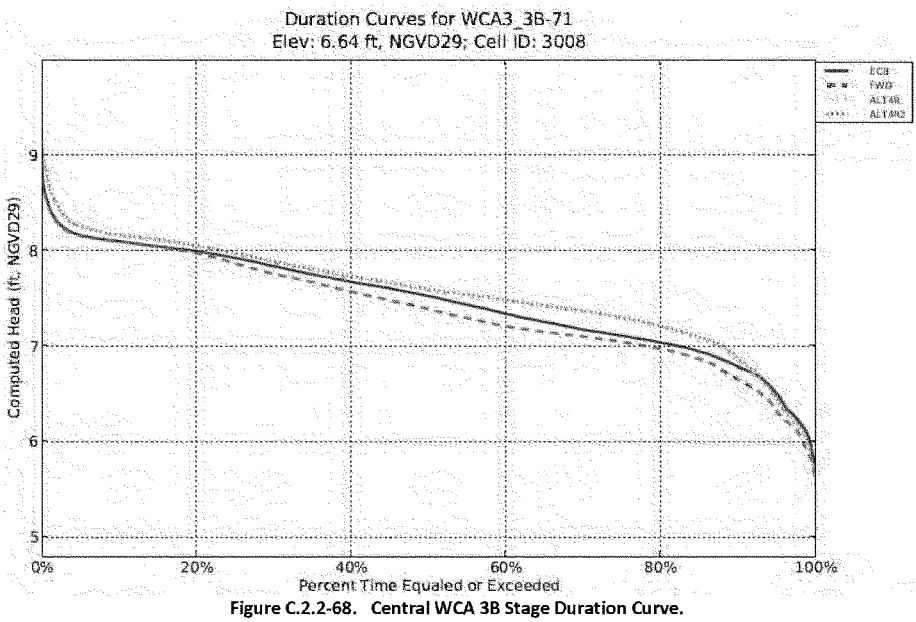


Figure C.2.2-68. Central WCA 3B Stage Duration Curve.

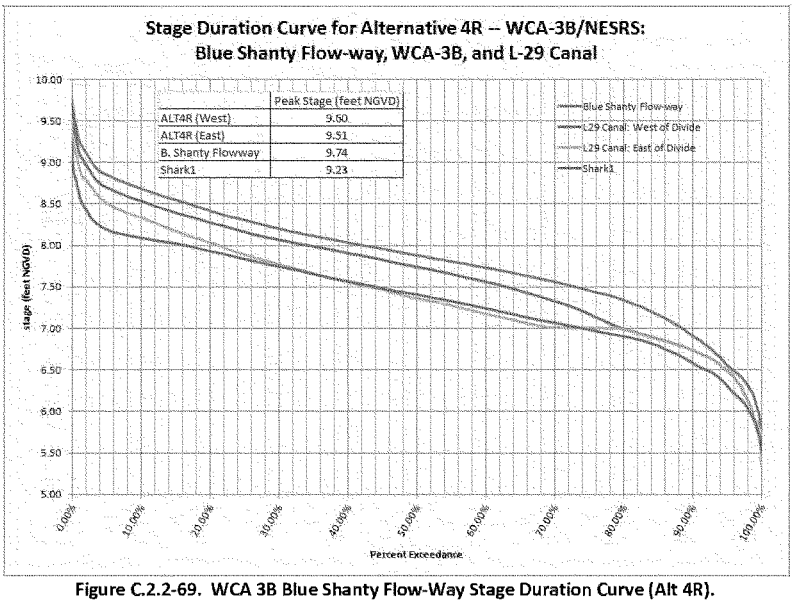


Figure C.2.2-69. WCA 3B Blue Shanty Flow-Way Stage Duration Curve (Alt 4R).

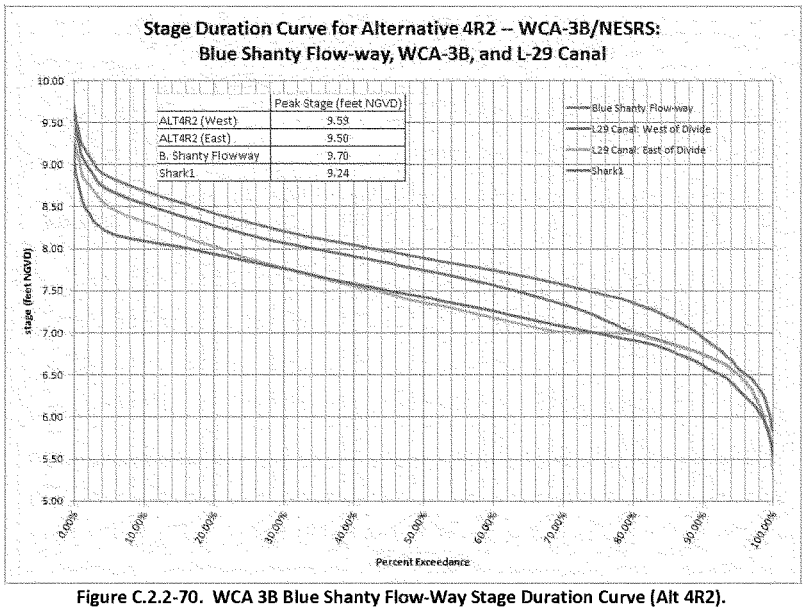


Figure C.2.2-70. WCA 3B Blue Shanty Flow-Way Stage Duration Curve (Alt 4R2).

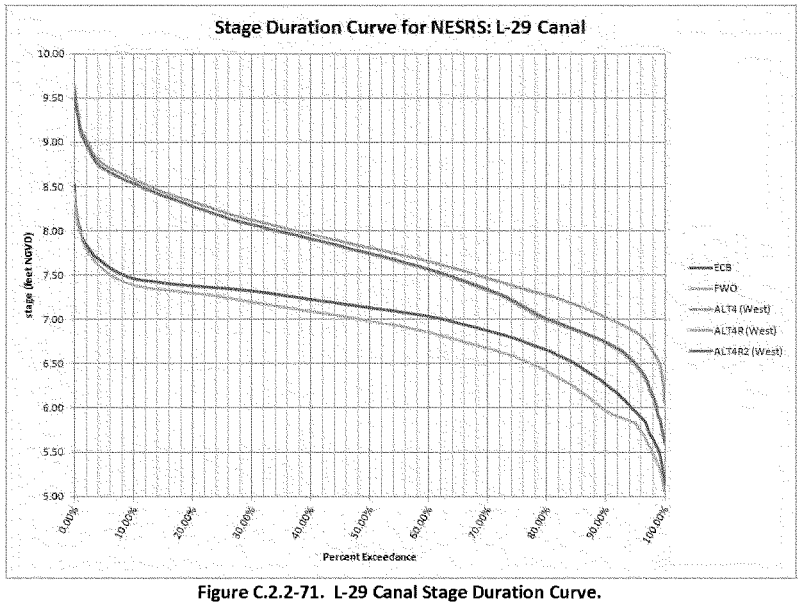


Figure C.2.2-71. L-29 Canal Stage Duration Curve.

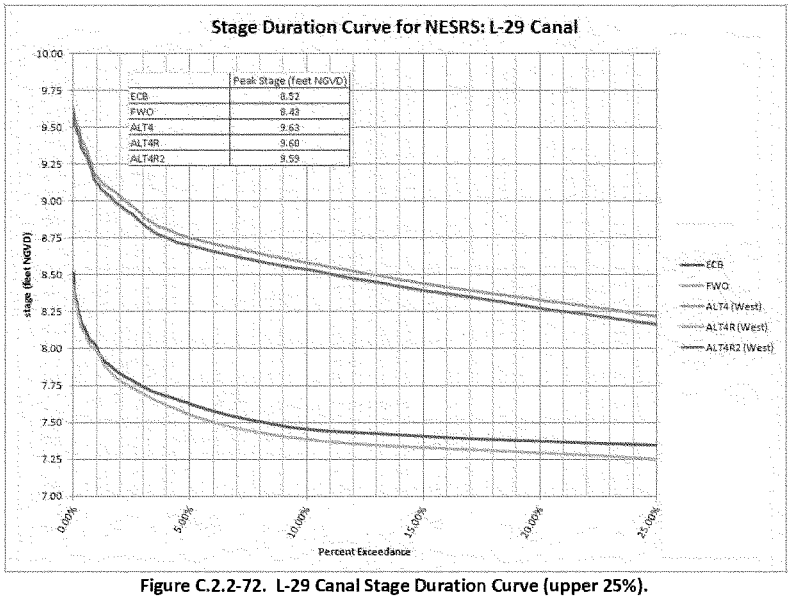


Figure C.2.2-72. L-29 Canal Stage Duration Curve (upper 25%).

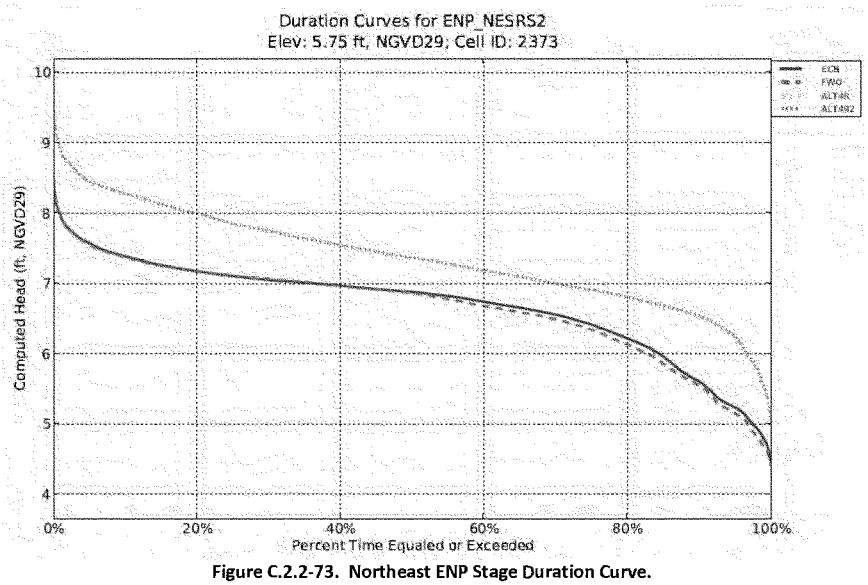


Figure C.2.2-73. Northeast ENP Stage Duration Curve.

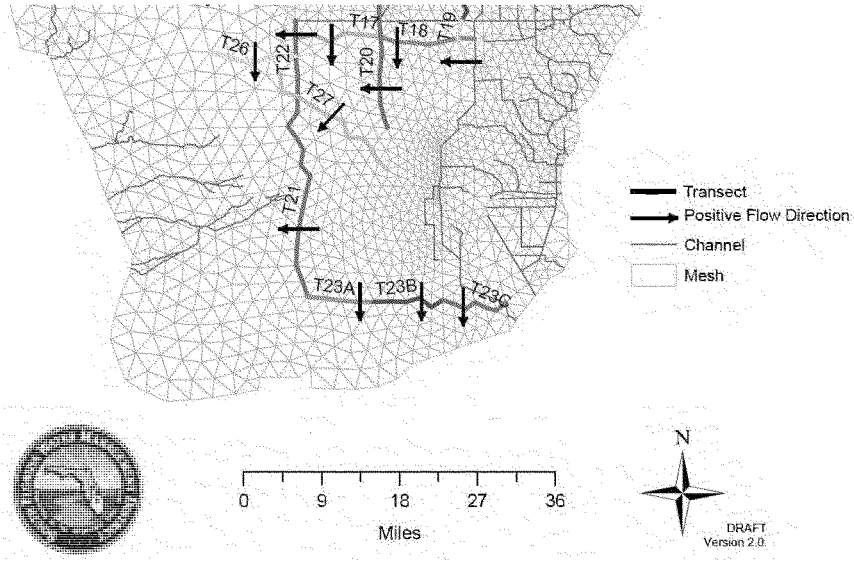


Figure C.2.2-74. RSM-GL Overland Flow Transects for ENP.

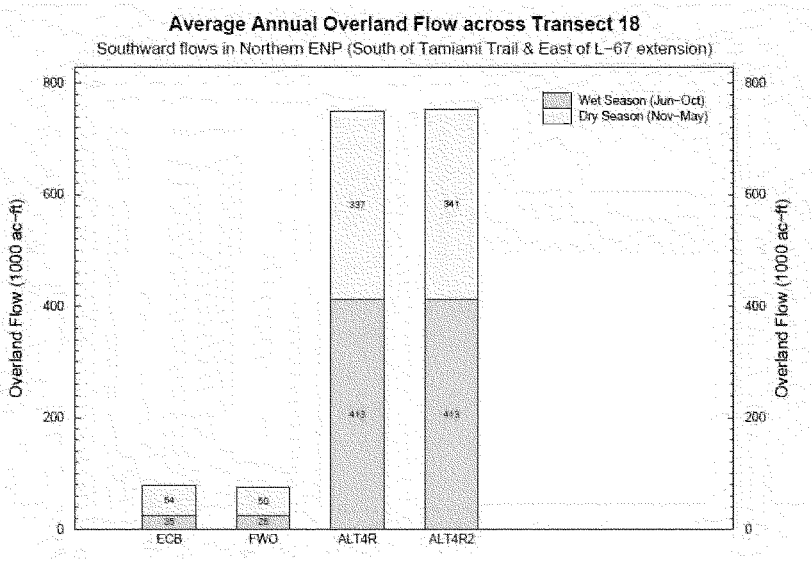


Figure C.2.2-75. Average Annual Overland Flow to NESRS.

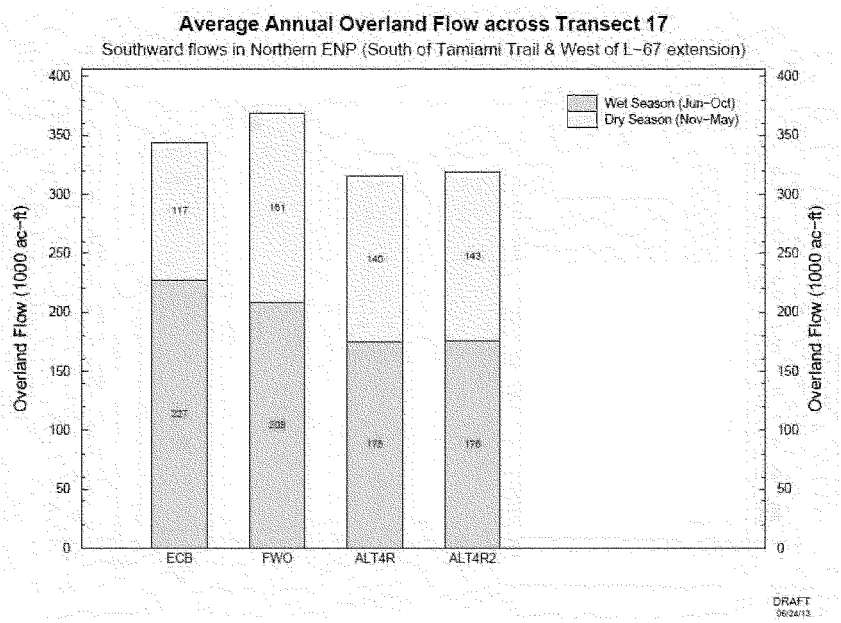


Figure C.2.2-76. Average Annual Overland Flow to WSRS.

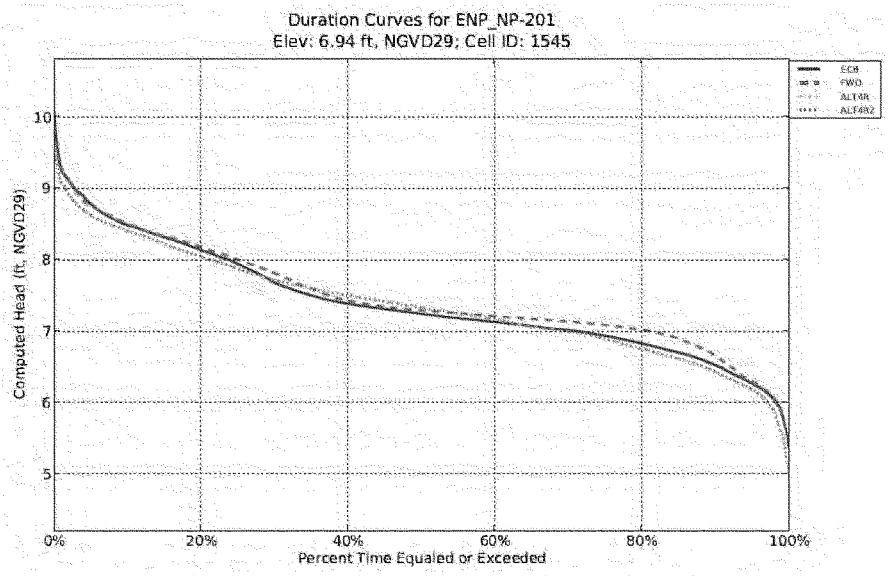


Figure C.2.2-77. Northwest ENP Stage Duration Curve (NP-201).

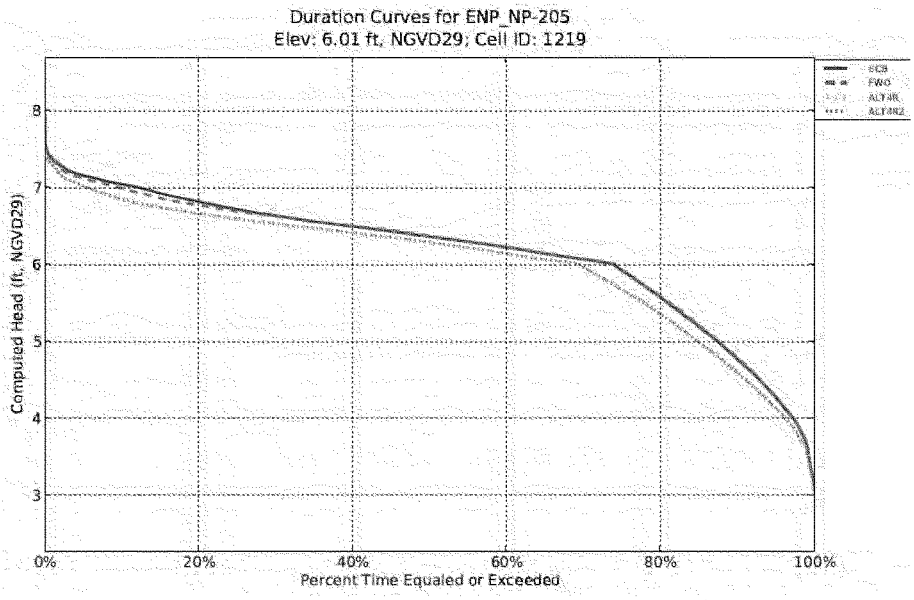


Figure C.2.2-78. Northwest ENP Stage Duration Curve (NP-205).

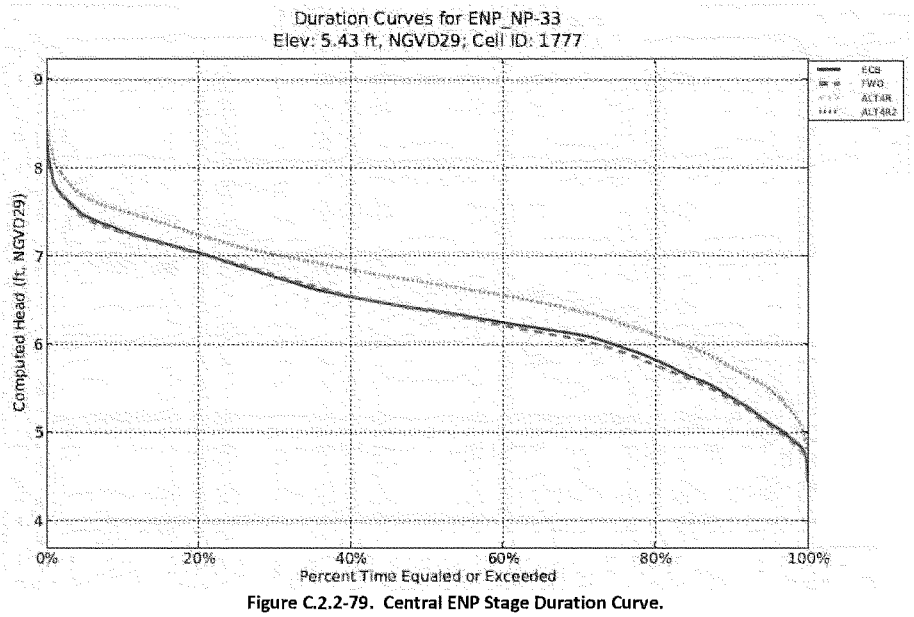


Figure C.2.2-79. Central ENP Stage Duration Curve.

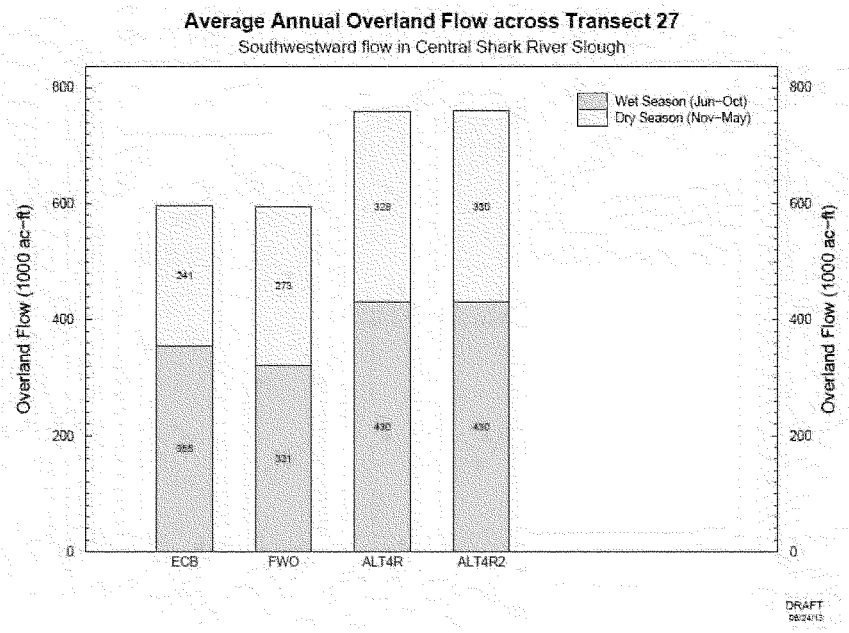


Figure C.2.2-80. Average Annual Overland Flow Transect for Central Shark River Slough.

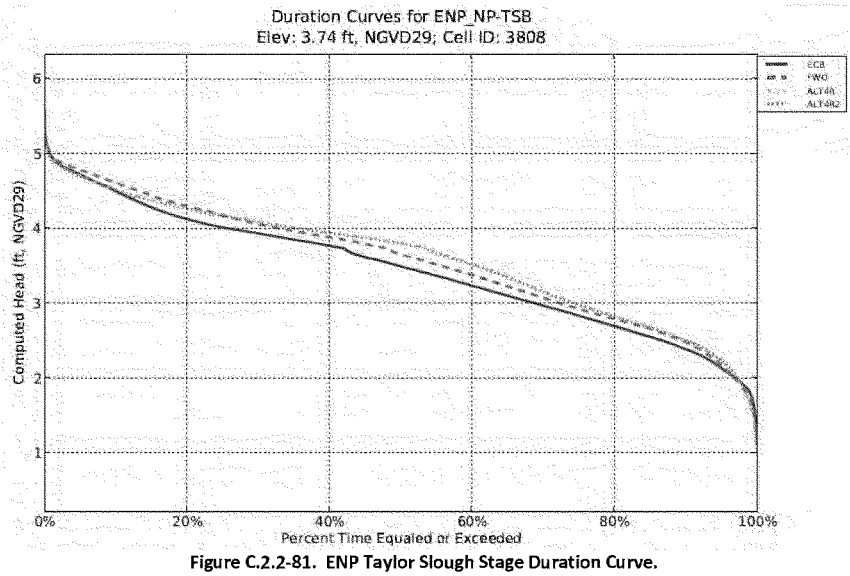


Figure C.2.2-81. ENP Taylor Slough Stage Duration Curve.

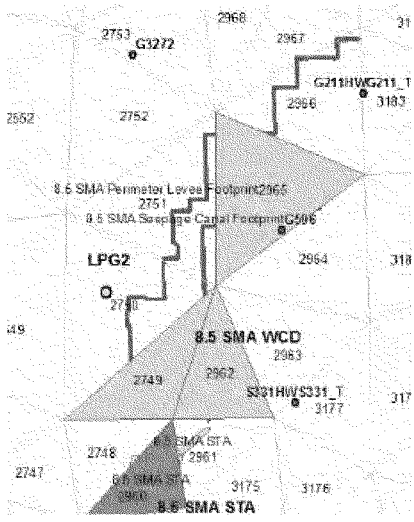


Figure C.2.2-82. RSM-GL grid cell representation of the 8.5 SMA

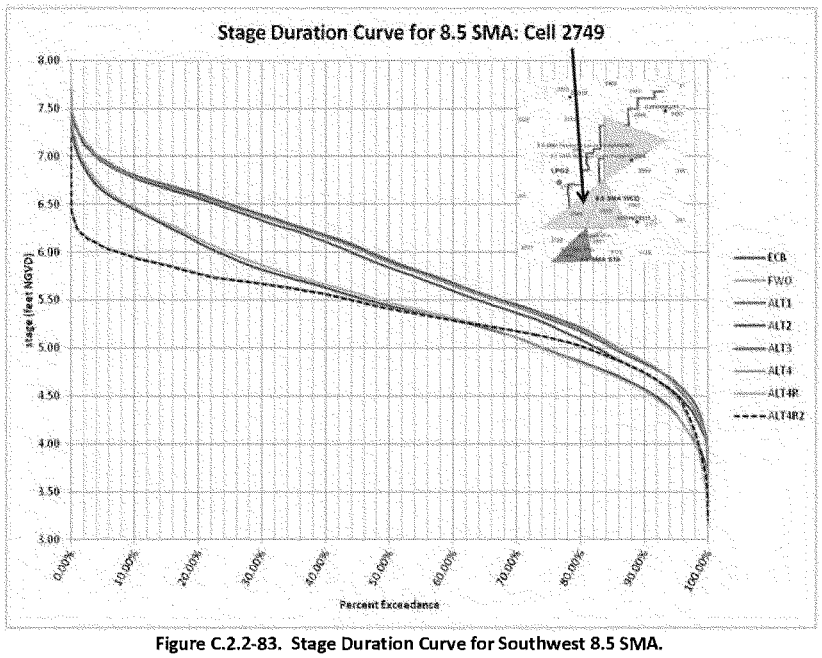


Figure C.2.2-83. Stage Duration Curve for Southwest 8.5 SMA.

C.2.2.8 Water Supply and Flood Control

Consistent with the Savings Clause requirements for CERP, each CERP project included in the CEPP FWO (Indian River Lagoon-South Project, Picayune Strand Restoration Project, Site 1 Impoundment Project, Biscayne Bay Coastal Wetlands Project, Broward County Water Preserve Areas Project, Caloosahatchee River (C-43) West Basin Storage Reservoir, C-111 Spreader Canal Western Project) must independently demonstrate in the respective PIRs that implementation of these CERP projects would not adversely impact the existing legal sources for water supply or the levels of service for flood protection. Operations protocols for the first and second generation CERP projects were modeled in the CEPP FWO consistent with the draft Project Operating Manuals, as documented in the respective PIRs. Operations and components of the previously listed CERP projects are retained Alt 4R and Alt 4R2, and the inclusion of the components is therefore implicit to the analyses within this section.

To address the Savings Clause requirements for CERP, the CEPP draft PIR/EIS includes a detailed and comprehensive analysis of potential effects of the CEPP recommended plan (Alt 4R2), where applicable, to existing legal sources for water supply and/or the levels of service for flood protection (refer to **Section 6** of the PIR main report for summary information and **Annex B** for the complete analysis). The general hydrologic overview of water supply and flood control performance of Alt 4R2 in this section is separate and distinct from the content of the recommended plan Savings Clause analysis contained in **Annex B**. Areas within the CEPP project area that are not specifically discussed in this section, such as the WCAs, may be presumed to have insignificant impacts to water supply or flood control.

C.2.2.8.1 Lake Okeechobee

Based on the modeling, compared to the FWO, the frequency of water restrictions enacted by the SFWMD Governing Board due to Lake Okeechobee falling below the Water Shortage Trigger line as defined by LOWSM is projected to slightly decrease for both Alt 4R and Alt 4R2: two fewer years with three or more months with restrictions for LECSA 1 (note: one additional year with restrictions, compared to the ECB); no change in the number of years with three or more months with restrictions for LECSA 2 (note: one fewer year with restrictions, compared to the ECB); and three fewer years with three or more months with restrictions for LECSA 3 (note: same number of years as the ECB).

As a result of the CEPP preliminary screening process, operational changes were incorporated into the hydrologic modeling conducted for the CEPP alternatives, including the Alt 4R and the recommended plan Alt 4R2, in efforts to optimize CEPP system-wide performance within the existing flexibility of the 2008 LORS. More specifically, the hydrologic modeling of the CEPP alternatives included proposed revisions to the 2008 LORS decision tree outcome maximum allowable discharges dependant on the following criteria: Lake Okeechobee inflow and climate forecasts (class limits were modified for tributary hydrologic conditions, seasonal climate outlook, and multi-seasonal climate outlook), stage level (regulation zone), and stage trends (receding or ascending). While some refinements were made within the operational flexibility available in the 2008 LORS, consistent with the original modeling intent, the final operational assumptions ultimately extended beyond this flexibility due to adjustments made to the tributary/climatological classifications. Minor modifications to the operational assumptions were included for Alt 4R and Alt 4R2, compared to Alts 1 through 4. For all CEPP alternatives, the LORS 2008 Regulation Schedule zones were unchanged. Additional information and documentation of these assumptions can be found in the Engineering Appendix **(Appendix A)** of the CEPP PIR.

Based on the modeling assumptions and the resulting moderate stage increases within Lake Okeechobee with Alt 4R and Alt 4R2, the average annual percentage of water supply demand not met is projected to decrease for the EAA and the remainder of the LOSA (**Figure C.2.2-84**). For the eight years

with the largest water supply cutbacks within the LOSA, the water supply cutback percentage with Alt 4R2 is reduced for seven of the eight years and increased for one of the eight years (1981), compared to the FWO (**Figure C.2.2-85**). For the eight years with the largest water supply cutbacks within the LOSA, the water supply cutback percentage with Alt 4R is reduced for six of the eight years and increased for two of the eight years (1981 and 1982), compared to the FWO.

Lake Okeechobee stage duration curves for the RSM-BN model representation of the CEPP ECB (LORS 2008), CEPP FWO (LORS 2008, plus additional CERP and non-CERP projects), and CEPP Alts 1 through 4R2 (LORS 2008, additional CERP and non-CERP projects, and prescribed operational flexibility) are shown in **Figure C.2.2-86**. A single RSM-BN simulation was originally completed for all of the CEPP components north of the red line for the final array of Alts 1 through 4, although separate RSM-BN simulations were later completed for both Alt 4R and Alt 4R2 to improve water supply performance within the LOSA with the recommended plan. Compared to the FWO, Alt 4R2 Lake Okeechobee stages are increased by 0.25-0.50 feet for the upper 70% of the stage duration curve, excluding extreme wet hydrologic conditions. Compared to the FWO, Alt 4R Lake Okeechobee stages are increased by 0.25-0.50 feet for the upper 60% of the stage duration curve, excluding extreme wet hydrologic conditions. Compared to Alt 4, Lake Okeechobee stages for Alt 4R and Alt 4R2 are slightly increased by less than 0.10 feet during the upper 40% of the stage duration curve. Peak lake stage increased from 17.50 feet NGVD in the FWO to 17.64 feet NGVD in Alt 4R and 17.66 feet NGVD for Alt 4R2.

The baselines, Alt 4R and the recommended plan Alt 4R2 all show simulated stages above 17.25 feet NGVD: 18 days for the ECB; 9 days for the FWO; 29 days for Alt 4R; and 29 days for Alt 4R2 (note: 14,975 days in the RSM-BN 41-year period of simulation). The USACE LORS 2008 Environmental Impact Statement (EIS) assessment recognized that minimizing the frequency of exceedance of the 17.25 feet elevation offers additional protection for public safety and the HHD, for the condition prior to completion of the current approved and planned HHD remediation measures, and this criterion was evaluated as a LORS project performance measure. Significant increases in the frequency, duration, and magnitude of Lake Okeechobee peak stages do not result from the assumed modified Lake Okeechobee operations with the CEPP alternatives (including Alt 4R and Alt 4R2), despite the assumed completion of HHD remediation measures, because the adverse ecological effects associated with increased lake stages and the associated increases in high volume releases to the estuaries were effectively balanced during the CEPP preliminary screening (for additional discussion of screening metrics, refer to **Section 3** of the PIR main report). Extreme high lake stages have also been documented to adversely impact the plant and animal communities, through processes which include the following: physical uprooting of emergent and submerged plants; reduced light levels in the water column due to increased suspended sediment; and littoral zone exposure to increased nutrient levels from the water column. The number of days with stages above 16 feet NGVD is increased from 696 in the FWO to 1157 in Alt 4R and 1162 in Alt 4R2 during the 1965-2005 period of simulation.

Following completion of the HHD remediation of Reaches 1, 2, and 3, the degree to which higher maximum lake stages and increased frequency and duration of high lake stages would be accepted, if at all, will be contingent on the conclusions identified in the USACE 2014 Dam Safety Modification Report (DSMR) for the Herbert Hoover Dike (HHD). Any changes to the Lake Okeechobee Regulation Schedule would be analyzed and coordinated with the public through the NEPA process.

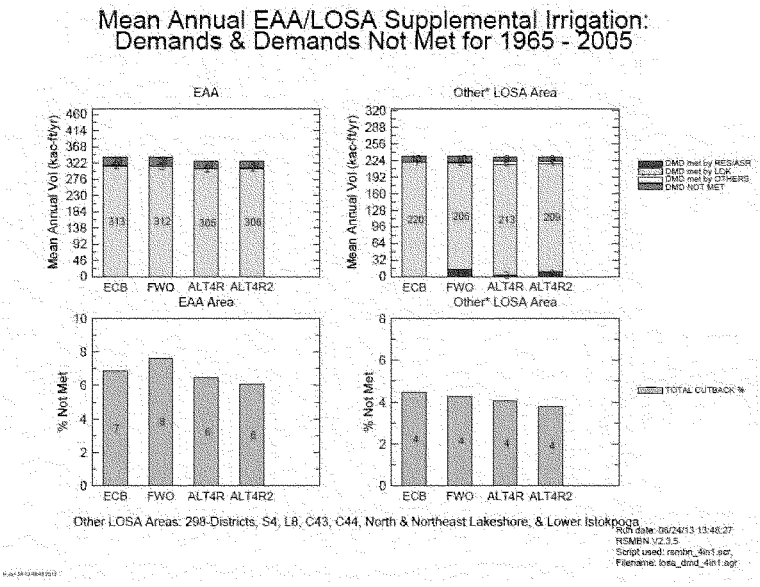


Figure C.2.2-84. EAA and LOSA Water Supply Performance.

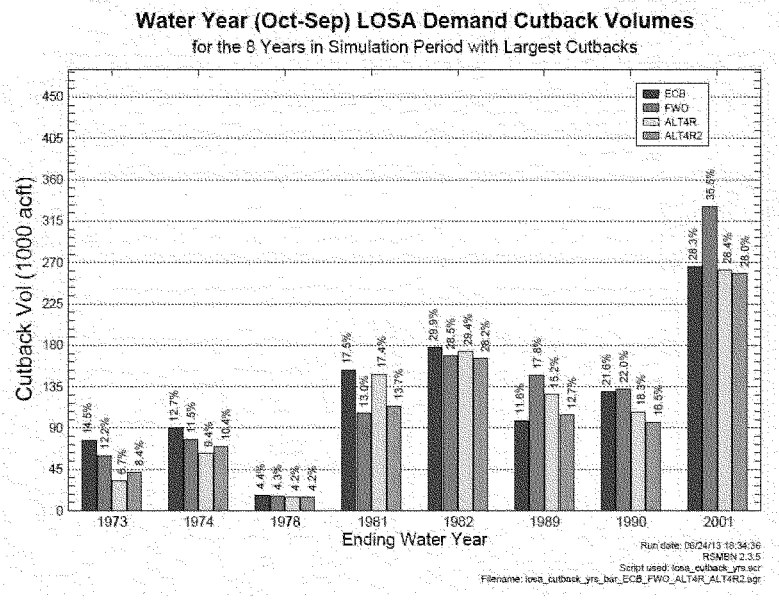


Figure C.2.2-85. LOSA Water Supply Performance for the Eight Largest Cutback Years.

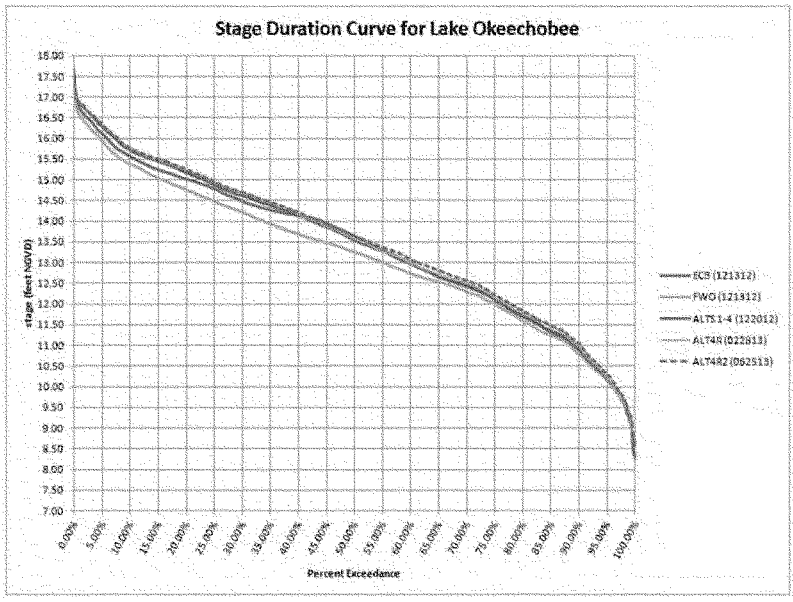


Figure C.2.2-86. Lake Okeechobee stage duration curves.

C.2.2.8.2 Seminole Tribe of Florida

Based on the CEPP alternative modeling assumptions regarding Lake Okeechobee operational flexibility and the resulting general moderate stage increases within Lake Okeechobee, the percentage of water supply demand not met for the Brighton Reservation is shown to slightly decrease by 0.5% for Alt 4R and by 0.8% for Alt 4R2 compared to the FWO (**Figure C.2.2-87**) (note: demand not met is also 0.3-0.6% lower than the ECB). The percentage of water supply demand not met for the Big Cypress Reservation is shown to be slightly reduced by 0.2% for Alt 4R and 0.4% for Alt 4R2 (**Figure C.2.2-88**) (note: demand not met is also 1.0-1.2% lower than the ECB). The Seminole Tribe of Florida has surface water entitlement rights pursuant to the 1987 Water Rights Compact and subsequent entitlement provisions executed between the Seminole Tribe of Florida, the State of Florida, and the SFWMD. Impacts are not expected for Alt 4R or Alt 4R2 based on the hydrologic modeling.

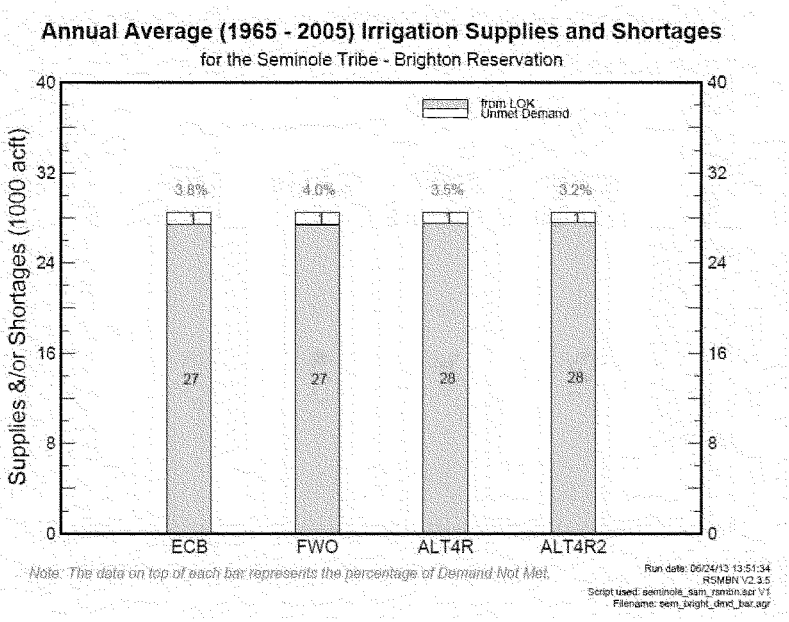


Figure C.2.2-87. Water Supply Demand for Seminole Tribe of Florida's Brighton Reservation.

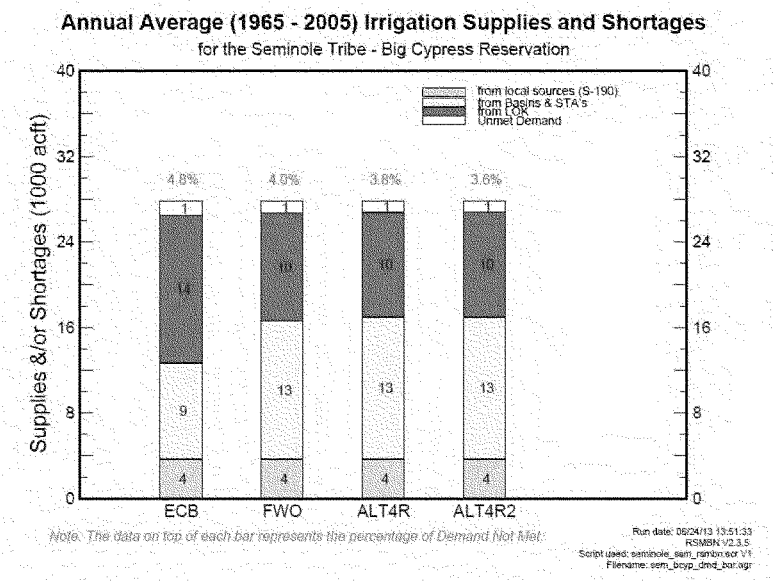


Figure C.2.2-88. Water Supply Demand for Seminole Tribe of Florida's Big Cypress Reservation.

C.2.2.8.3 Lower East Coast Service Areas

Based on the alternative modeling, compared to the FWO, the frequency of water restrictions enacted by the SFWMD Governing Board due to Lake Okeechobee falling below the Water Shortage Trigger line as defined by LOWSM is projected to slightly decrease for both Alt 4R and Alt 4R2: two fewer years with three or more months with restrictions for LECSA 1 (note: one additional year with restrictions, compared to the ECB); no change in the number of years with three or more months with restrictions for LECSA 2 (note: one fewer year with restrictions, compared to the ECB); and three fewer years with three or more months with restrictions for LECSA 3 (note: same number of years as the ECB). For the LECSA, additional water has been made available with Alt 4R2 in the regional system and has been quantified for LECSA 2 and LECSA 3. An increased demand of 12 million gallons per day (MGD) in LECSA 2 and 5 MGD in LECSA 3 was included in Alt4R2 above the demands in the FWO baseline; the public water supply demands assumed for the FWO are also equivalent to the demands assumed for the ECB and 2012EC existing condition baselines. This increase in demands for other water related needs was able to be provided without adversely affecting the benefits accrued in the natural system.

Alternative 4R and Alt 4R2 modeling also indicate no significant reductions to regional groundwater stages during dry conditions (assumed as a surrogate for water supply conditions for this discussion) for most portions within the LECSA, as compared to the FWO condition. No significant changes were indicated within LECSA 1, LECSA 2, and most of LECSA 3 that were prevalent through normal to dry hydrologic conditions. For Alt 4R, some reduced stages were indicated during the driest 5-10% of hydrologic conditions for areas east of WCA 2A and WCA 2B (monitoring gages G2031, G2033, and G2032) and during the driest 5% of hydrologic conditions for areas east of L-31N and south of the 8.5 SMA (monitoring gages G1362, G1363, G614, and G757A). The modified L-6 diversion operations applied for Alt 4R2 resulted in increased dry period stages within WCA 2B, and Alt 4R2 does not indicate reduced stages for areas east of WCA 2A and WCA 2B (monitoring gages G2031, G2033, and G2032) that were affected with Alt 4R. Alt 4R2 continues to indicate reduced stages during the driest 5% of hydrologic conditions for areas east of L-31N and south of the 8.5 SMA (monitoring gages G1362, G1363, G614, and G757A). In general, lowered regional groundwater stages during dry conditions that were apparent for the FWO when compared to the ECB are not further exacerbated by Alt 4R or Alt 4R2.

For Alt 4R and Alt 4R2, compared to the FWO, L-30 Canal stages (north of S-335) are generally increased by 0.1-0.6 feet for normal to extreme dry conditions (**Figure C.2.2-89**); L-30 Canal stages also show an increase of 0.2-0.4 feet compared to the ECB for the driest 20% of hydrologic conditions. L-30 Canal stages are highly correlated to hydrologic conditions within central and eastern WCA 3B. L-31N Canal stages (north of G-211) are increased by 0.1-0.2 during dry conditions for Alt 4R and Alt 4R2, with no significant change compared to the ECB and FWO during normal hydrologic conditions (**Figure C.2.2-90**). No significant stage reductions within the C-111 Canal (between S-176 and S-18C) are indicated during normal to dry hydrologic conditions that would affect water supply deliveries, and both Alt 4R and Alt 4R2 performance indicates a 0.1-0.2 feet stage increase during normal hydrologic conditions compared to both ECB and FWO (**Figure C.2.2-91**).

The Alt 4R and Alt 4R2 modeling indicates no significant increases to regional groundwater stages during wet conditions which would impact the levels of service for flood control within the LECSA, as compared to the FWO condition. No significant changes were indicated within LECSA 1, LECSA 2, and significant reductions were observed for portions of LECSA 3. For Alt 4R2, LEC monitoring gauge stages immediately east of the Pennsuco wetlands (east of WCA 3B), specifically G3259A (**Figure C.2.2-92**), USGS-02297497, and C2_74, indicate a minor increase to stages in the wettest 10% of the stage duration

curve, with stage increases of less than 0.20 feet; however, in all cases, Alt 4R2 stages are the same or lower than the ECB base condition for the wettest 10% of the stage duration curve. The L-30 Canal stages (north of S-335) for Alt 4R and Alt 4R2 indicate a moderate reduction of 0.1-0.2 feet to flood control stages within the wettest 10% of hydrologic conditions, with no significant change observed for the upper 1% of the stage duration curve (**Figure C.2.2-89**). The L-31N Canal stages (north of G-211) indicate a significant (up to 1.0 feet) reduction to flood control stages within the wettest 5% of hydrologic conditions for Alt 4R and Alt 4R2 (**Figure C.2.2-90**). C-111 Canal stages between S-176 and S-18C indicate no significant change for the upper 10% of the stage duration curve compared to the FWO, with a small stage reduction of 0.1 feet observed compared to the ECB (**Figure C.2.2-91**).

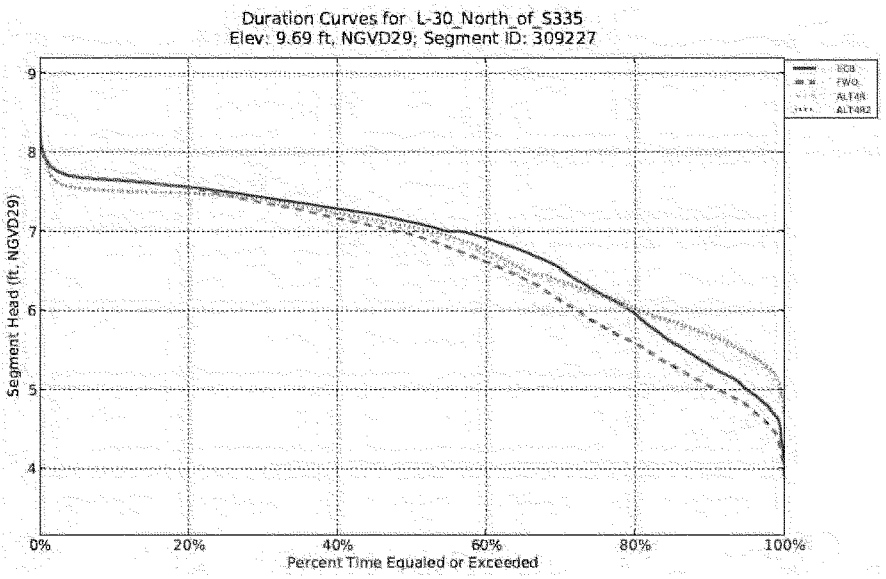


Figure C.2.2-89. Stage Duration Curve for L-30 Canal in LECSA 3.

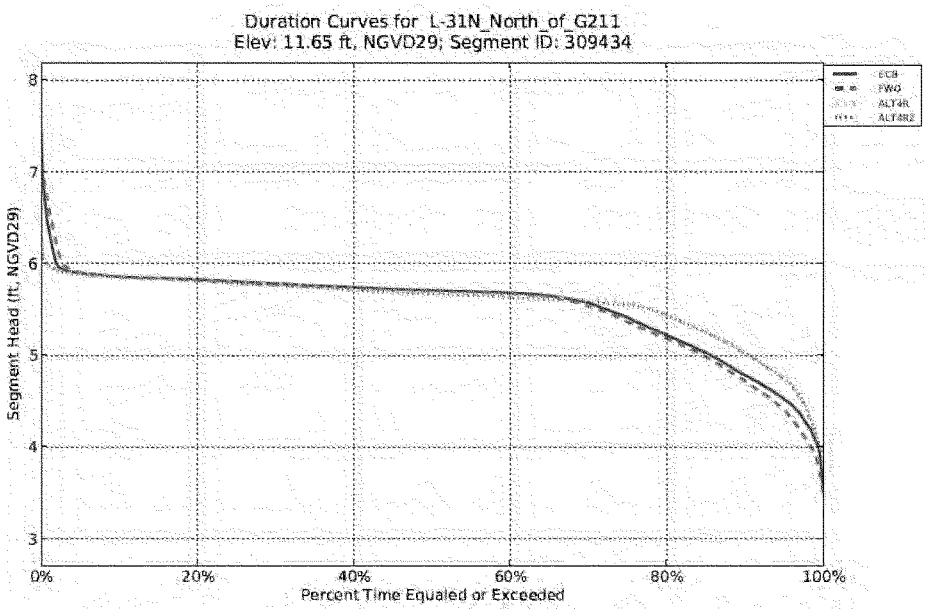


Figure C.2.2-90. Stage Duration Curve for L-31N Canal in LECSA 3.

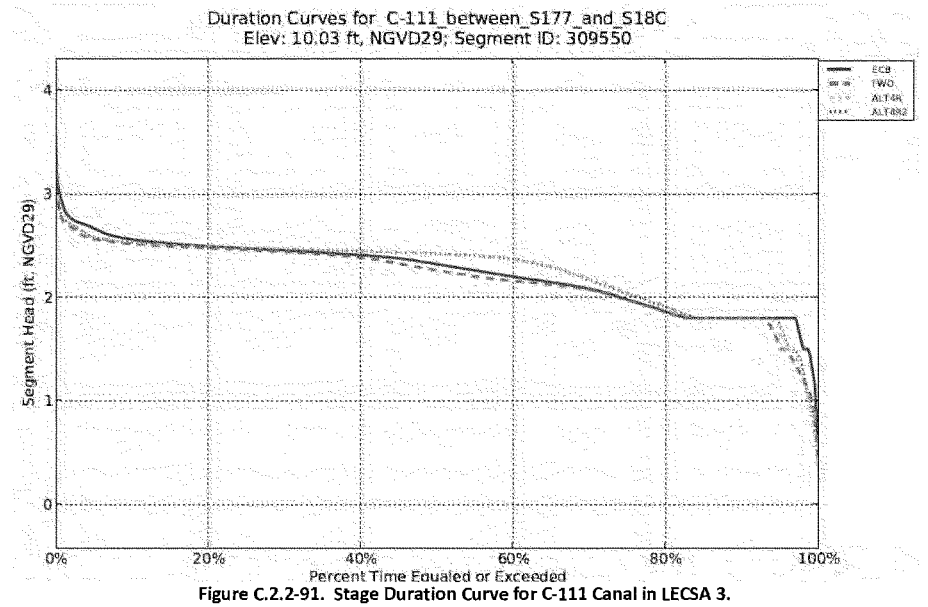


Figure C.2.2-91. Stage Duration Curve for C-111 Canal in LECSA 3.

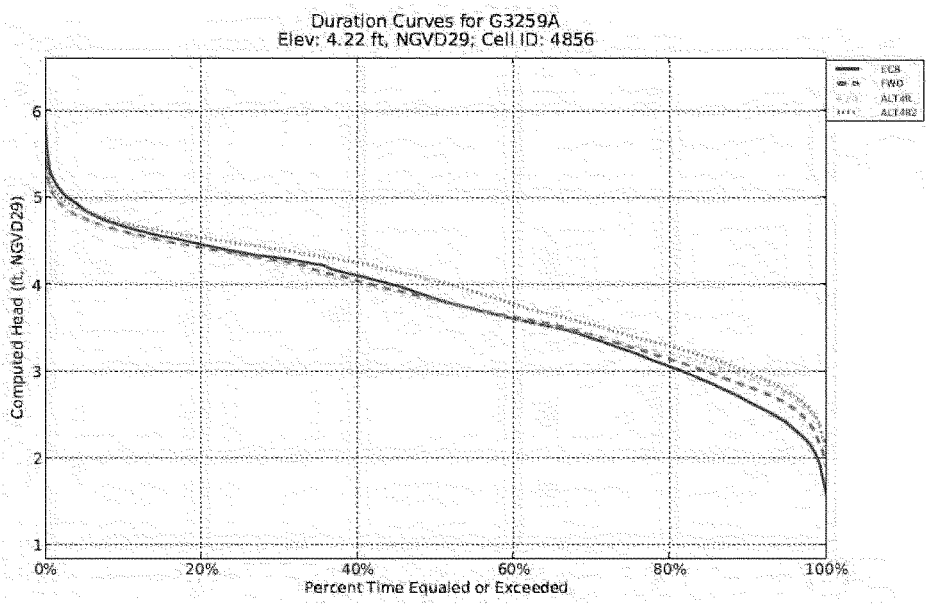


Figure C.2.2-92. Stage Duration Curve for G-3259A in LECSA 3.

C.2.2.9 Water Quality

Water quality impacts from Alt 4R and Alt 4R2 are considered to be nearly identical given that these alternatives have identical project features and nearly identical operating criteria. Discussion of the water quality impacts of Alt 4R apply equally to Alt 4R2.

C.2.2.9.1 Lake Okeechobee

Relative to the FWO project, Alt 4R will likely result in some improvement in Lake water quality as a result of reduced extreme lake stage events. However, the expected improvement will likely not be very significant since nutrient loading conditions are not expected to differ between FWO and Alt 4R. Methyl-mercury bioaccumulation potential in the lake is not expected to change. As discussed in the existing conditions section for Lake Okeechobee, there is an existing TMDL for phosphorus. This TMDL requires a reduction in annual phosphorus loading from more than 500 metric tons per year to 140 metric tons per year. The average annual S-308 backflow of 2.6 metric tons per year under the existing condition and 4.6 metric tons/yr under the with-project condition. . The increase of 2 metric tons per year amounts to less than 1.5 percent of the phosphorus TMDL target of 140 metric tons/yr. The allocation of TMDL phosphorus loads will be addressed through revisions to the Lake Okeechobee Basin Management Action Plan. Specifically, the FDEP is in the process of developing a BMAP for Lake Okeechobee pursuant to Section 403.067, Florida Statutes. Potential water quality issues associated with S-308 loads will be addressed as part of the BMAP.

C.2.2.9.2 Northern Estuaries

Caloosahatchee: Improved salinity conditions within this estuary as a result of a reduction in the number of high flow events and a reduction in the number of extreme low flow events as characterized

by flows through the S-79 structure. Nutrient and dissolved oxygen conditions should improve slightly during the wet season within the estuary given the reduction in high flow events. The frequency of dry season algal events within the upper estuary may change as a result of increased dry season flows through the S-79 structure during the late spring.

St. Lucie Estuary: Improved salinity conditions within this estuary as a result of a reduction in the number of high flow as characterized by flows through the S-80 structure. Nutrient and dissolved oxygen conditions should improve during the wet season within the estuary given the reduction in high flow events. The number of months of flow less than 300 cfs decreases so there may be some change in the frequency of algal blooms during the later part of the dry season.

C.2.2.9.3 EAA

With-Project Alternatives vs. FWO

Alternative 4R and Alt 4R2 include the A-2 FEB integrated into the A-1 FEB along with additional Lake Okeechobee water distributed south of the EAA. Dynamic Model for Stormwater Treatment Areas (DMSTA) water quality modeling indicates that the with-project alternatives will meet the 2012 Water Quality-based Effluent Limits (WQBEL).

C.2.2.9.4 Greater Everglades

WCA 1, WCA 2

Water quality conditions for WCA 1 are not expected to be significantly changed by Alt 4R since it does not include features that influence flows and treatment within the eastern flow path. Nutrient and sulfate loading conditions in WCA 2 should improve somewhat given the reduction in hydrologic load sent to this water conservation area. Reduced nutrient and sulfate loading could somewhat alter the locations where mercury methylation is problematic within WCA 2.

C.2.2.9.5 WCA 3A

Phosphorus loading into the northern portion of WCA 3A is expected to increase by about 10 percent relative to the FWO condition as a direct result of the increase in hydrologic loading; however, relative to the existing condition, phosphorus loads from Alt 4R will be reduced by approximately 25 percent. Phosphorus concentrations in water discharged into WCA3A are expected to be lower by approximately 1/3rd relative to existing conditions. Sulfate concentrations into the northern portion of WCA 3A are expected to decrease with Alt 4R as a result of the additional dilution of EAA runoff with Lake Okeechobee discharges which have sulfate concentrations roughly half that of the EAA runoff. The total load of sulfate into WCA3A is expected to increase from 5 to 10 percent over FWO.

Figure C.2.2-93 shows the average annual flow across three transects in WCA 3A. A comparison of total flow to the surface water flow for these three transects shows that surface water flows dominate the flow. Increased nutrient uptake in the northern portion of WCA 3A will likely result in reduced TP concentrations at the southern end of this WCA as compared with the FWO condition which has significant canal flows that provide less nutrient uptake than sheetflow across the marsh. It is likely that northern portions of the WCA 3A marsh that are adjacent and south of the L-4, and L-5 canals will experience higher TP loads as compared to the FWO. This will cause the conversion of some areas of native vegetation to less desirable cattail. A detailed discussion of CEPP impacts to phosphorus loads and concentrations in WCA 3A is provided in **Annex F**.

The methylmercury cycle is very complex with many factors affecting bioaccumulation in fish. Changes in hydrology can impact the formation of methylmercury. For instance, Alt 4R will reduce

dryout/rewetting cycles in northern WCA 3A which will reduce sulfate and Hg remobilization due to soil oxidation. Project related changes to the timing, distribution, and loading of sulfate in WCA 3A will likely alter the locations where methylated mercury is found at high concentrations in the water column. This is illustrated in **Figure C.2.2-94** from the 2013 SFER report which projects the impact to mosquitofish mercury body burden of reducing by 50 to 100 percent the agriculturally sourced sulfate discharged into the Everglades Protection Area. This figure shows that significant decreases in sulfate loading would both increase and decrease mosquitofish mercury concentrations in WCA 3A depending upon the location. A 100 percent reduction in non-marine sulfate exported from the EAA is projected to result in an overall reduction in average water column sulfate concentrations within the Everglades Protection Area from 2.4 mg/L to 0.78 mg/L; however, the average mosquitofish mercury concentration is estimated to be reduced from 85.7 ng/g to 80.0 ng/g which is a relatively insignificant change in proportion to the reduction in sulfate. Though these projections are for decreases in sulfate rather than increased sulfate loading, they are indicative of the relative insensitivity of mosquitofish methylmercury bioaccumulation to relatively small changes (<10 percent increase) in sulfate loading as contemplated with Alt 4R and Alt 4R2.

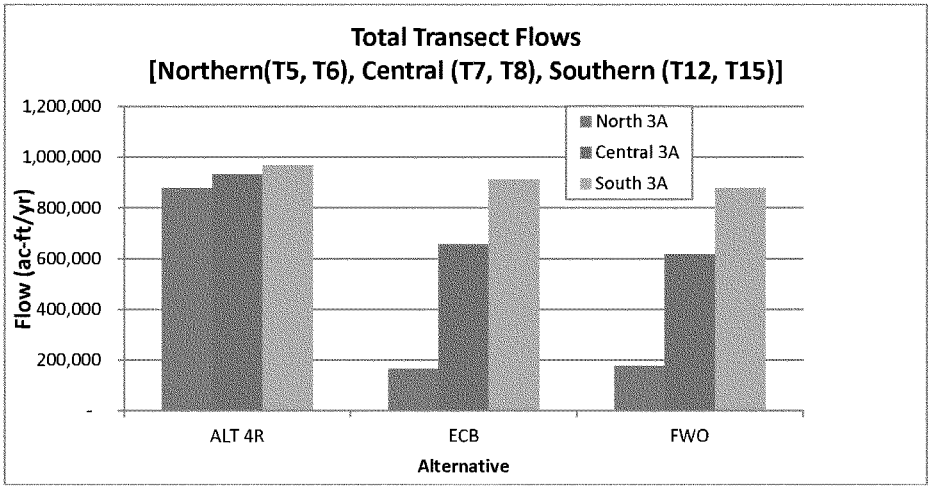


Figure C.2.2-93. Average Annual Surface and Groundwater Transect Flows for WCA 3A.



Figure C.2.2-94. Predicted changes in *Gambusia* Hg concentrations in response to 50 and 100 percent reductions in excess (non-marine) sulfate exported from the EAA (left and right, respectively) using R-EMAP Cycles 6 and 7 data. (from SFWMD, 2012).

C.2.2.9.6 WCA 3B

Additional water flow into WCA 3B will result from the breaches of the L-67A and L-67C levees. Relative to the FWO condition, flows through these breaches will be composed of more water that passes through the northern WCA 3A marsh and less water from the Miami Canal and the S-9 basin since these flows are reduced by approximately 50% at S-151 and 9% from S-9/S-9A pumps. Increased hydration of WCA 3B will reduce the risk for severe dry down and thus reduce fire risk relative to FWO. Water quality degradation such as the release of Total Phosphorous (TP) into the water column and increased methyl mercury (MeHg) in the water column associated with fire events and their aftermath will be reduced. Additional flow into WCA 3B will increase nutrient loads relative to the FWO condition. **Annex F** includes a detailed discussion of the impact of CEPP on phosphorus within WCA 3B.

Like WCA 3A, sulfate loads are likely to increase in WCA 3B due to increased flows into this area relative to the FWO condition. Less frequent dryout/rewetting cycles within this area should reduce soil oxidation and the resulting recycling of sulfate and mercury back into the water column. The effects of additional sulfate on water column methylmercury concentrations and total mercury body burden in fish and birds in WCA 3B cannot be predicted with certainty. In light of this uncertainty, there is no reason to predict that the CEPP project will result in bioaccumulation that exceeds historic mercury concentration maximums unless atmospheric mercury deposition increases over present rates. The

recent downward trends in measured water and tissue mercury concentrations in this area are encouraging.

C.2.2.9.7 Everglades National Park

C.2.2.9.7.1 Shark River Slough

Alternative 4R2 vs. FWO

Water entering Shark River Slough (SRS) from WCA 3 is likely to have lower concentrations of TP as compared with the FWO condition due to the backfilling of the Miami Canal which will result in more water passing through the marsh areas and less water flowing directly from upstream canal sources. A detailed discussion of the effect of the CEPP project on total phosphorus concentrations in ENP is provided in **Annex F**.

Fish mercury concentrations within ENP have not decreased as much as that observed in WCA 3. The reasons for continued higher concentrations of bioaccumulated mercury in ENP fish are not well understood at this time due to the complexity of processes involved. The range of sulfate concentrations that maximize methylmercury formation in ENP may differ from that in the water conservation areas (SFWMD, 2011). The effect that small changes in sulfate in ENP would have on fish mercury are difficult to predict.

Sulfate loading into ENP under the Alt 4R2 condition is likely to decrease somewhat relative to the FWO condition primarily because most of the flows into northern ENP will have been routed through the WCA 3 marsh which is likely to remove more sulfate than the additional sulfate provided by the increased flow from Alt 4R2. The additional flow will increase stages within Shark River Slough by an average of 0.5 ft which should significantly reduce areas that are subject to dry out and rewetting. Reduced dry out and rewetting will reduce the recycling of sulfate and mercury that exacerbates mercury bioaccumulation. The effects of Alt 4R2 on formation and bioaccumulation of methylmercury cannot be predicted with certainty since the mechanisms that affect mercury methylation rates in ENP are not fully understood at this time. However, if sulfate loads do not increase with Alt 4R2 and the additional flow reduces dry out/rewetting cycles, it is likely that future with-project mercury methylation conditions will not exceed the peak concentrations observed in ENP in 1999 unless atmospheric deposition of mercury increases in the future. Continued monitoring and scientific investigation of mercury within the Everglades Protection Area will provide more certainty regarding potential project impacts well before the additional flows from Alt 4R2 are realized.

C.2.2.10 Air Quality

Direct emissions from the proposed construction of the CEPP project features would be confined to exhaust emissions of labor transport equipment, and construction equipment (dump trucks, excavators, graders, bulldozers, etc.). Clean Air Act pollutants considered in this air quality assessment are SO_x; volatile organic compounds (VOCs); nitrogen oxides (NOx), CO, PM10, and PM2.5. Green house gas emissions are also considered. Volatile organic compounds, sulfer oxides, and nitrogen oxides are important since they are precursors to ozone generation. These criteria pollutants are generated by the construction and operational activities associated with the proposed alternatives.

Pursuant to the General Conformity Rule, of the Federal Clean Air Act (CAA) as promulgated by the U.S. Environmental Protection Agency (EPA), a federal agency must make a General Conformity Determination for all federal actions in non-attainment or maintenance areas where the total of direct and indirect emissions of a non-attainment pollutant or its precursors exceeds levels established by the regulations. Since Palm Beach, Broward, and Miami-Dade Counties are considered by EPA to be in

attainment for all criteria pollutants, the proposed recommended plan for CEPP is exempt from CAA Conformity Determination requirements. The criteria pollutants, including ozone, are estimated herein for planning purposes only.

C.2.2.10.1 Emission Sources

The emission rate factors shown in **Table C.2.2-8** for equipment such as excavators, dozers, dump trucks, and the associated support equipment, were derived from a USEPA non-road engine emissions modeling report USEPA, 2002). The number, type, and duration of use for each piece of equipment were estimated using preliminary earth moving volumes estimated for each of the project features.

Table C.2.2-8. Emission Rate Factors for Construction Equipment Likely to Be Used to Construct CEPP ALT 4R2 Project Features.

Equipment	HP	Load Factor	Emission Factors in g/bhp-hr					
			CO	VOC	Nox	Sox	PM10	PM2.5
Tractor with bush hog	108	0.21	4.07	1.19	7.16	0.007	0.654	0.582
Dozer	140	0.58	2.19	0.59	6.15	0.006	0.229	0.204
Off Road Dump Truck	300	0.57	1.82	0.57	5.55	0.006	0.295	0.263
Road Grader	165	0.59	2.19	0.59	6.15	0.006	0.229	0.204
Roller	106	0.43	4.08	1.32	7.76	0.007	0.686	0.611
Scraper	250	0.7	2.45	1.32	7.76	0.007	0.686	0.611
Trac-hoe	270	0.59	2.19	0.59	6.15	0.006	0.229	0.204

C.2.2.10.2 Emission Calculations

Project related air pollution emissions were estimated for each of the constructed features included in the selected plan (Alt 4R2) these estimates are considered to be applicable to the other with-project alternatives. The construction effort for each project feature was derived from very rough estimates of the volume of earth material moved for each features, the likely construction methodology, and the estimated drive distance between material excavation and material placement. To account for emissions from activities not directly associated with earth moving, the estimates were increased by 20 percent. The duration of construction for each project feature was determined using the probable maximum annual expenditure and the estimated construction cost of the feature. For instance, if the feature is estimated to cost $400 million and the probable maximum annual construction budget is $100 million per year, the duration of construction for that feature was estimated to take four years. Since the sequencing of activities required to build an individual project feature is not available in the planning phase, all construction tasks were spread out over the entire duration of construction of the feature. Emission rates, reported in tons of pollutant emitted per year of operation (tons/year) for each engine were calculated for each of the six criteria air pollutants: CO, NOx, PM2.5, PM10, SOx, and VOCs. The emission rates were derived from the formula:

Emission Rate (tons/yr) = Engine Horsepower × *Engine Load Factor* × *Emission Factor* × duration of operation over the year

Green house gas emissions (carbon dioxide) were estimated based upon the diesel fuel consumption for each feature.

C.2.2.10.3 With Project Construction Emissions

The criteria air pollutants emissions shown in **Table C.2.2-9** are the estimated total of direct and indirect emissions that would occur during the construction of the CEPP project features. The project features included are:

L-5: L-5 Canal Capacity Expansion
MCB: Miami Canal Backfill
BSL: Blue Shanty Flow-way Levee
DGRD: Degrade of the L-67E, L-67A, L-67C, L-29 levee
A2: A-2 FEB
SB: L-29N Seepage Barrier

The emissions from the construction of pump stations and flow control structures are accounted for in the 20 percent contingency factor applied to the total loads.

Table C.2.2-9. Estimated Air Pollutant Emissions from the Construction of ALT 4R2.

Feature Construction		Regulated Air Pollutants						Green House Gas Emissions	
	Year	CO	VOC	Nox	Sox	PM10	PM2.5	Fuel Burnt	CO2
		Mton/yr	Mton/yr	Mton/yr	Mton/yr	Mton/yr	Mton/yr	gallons/yr	Mtons/yr
L-5	1	27.8	8.3	82.5	0.1	4.0	3.5	453,333	4,565
L-5	2	27.8	8.3	82.5	0.1	4.0	3.5	453,333	4,565
MCB	3	23.9	7.2	71.2	0.1	3.5	3.1	465,000	4,683
MCB	4	23.9	7.2	71.2	0.1	3.5	3.1	465,000	4,683
MCB	5	23.9	7.2	71.2	0.1	3.5	3.1	465,000	4,683
MCB	6	23.9	7.2	71.2	0.1	3.5	3.1	465,000	4,683
BSL	7	12.0	4.3	34.2	0.0	2.0	1.8	212,654	2,141
DGRD	8	7.8	2.1	21.8	0.0	0.8	0.7	162,000	1,631
DGRD	9	7.8	2.1	21.8	0.0	0.8	0.7	162,000	1,631
DGRD	10	7.8	2.1	21.8	0.0	0.8	0.7	162,000	1,631
DGRD	11	7.8	2.1	21.8	0.0	0.8	0.7	162,000	1,631
DGRD	12	7.8	2.1	21.8	0.0	0.8	0.7	162,000	1,631
A2	13	15.4	5.4	43.3	0.0	2.5	2.2	309,421	3,116
A2	14	15.4	5.4	43.3	0.0	2.5	2.2	309,421	3,116
A2+SB	15	17.7	6.1	50.2	0.0	2.8	2.5	353,421	3,559
A2+SB	16	17.7	6.1	50.2	0.0	2.8	2.5	353,421	3,559
Totals		**268**	**83**	**780**	**1**	**38**	**34**	**5,115,006**	**51,508**

C.2.2.10.4 With Project Operational Emissions

Operational emissions estimates are assumed to be generated primarily from the pumps moving water into the A-2 FEB and from the enlarged S-356 pump station (**Table C.2.2-10**). The pump stations feeding the A-2 FEB is the S-370 and the S372 pumps. The NOx and SOx loads are taken from Golder Associates,

2010. The other pollutants loads were estimated from the Golder Associates NOx emissions. The A-2 FEB emissions and the ratio of A-2 FEB flows to S-356 flows were used to estimate the S-356 emissions. Emissions associated with employee transportation and maintenance of ALT4R features are not presented here because they should be minor in comparison to the emissions from the major pump stations. Emissions associated with the Alt 4R will result in minor, localized, temporary increases in concentrations of NO_2, SO_2, CO, VOC, and PM. Since the project is located in an attainment area, there is no requirement to prepare a conformity determination. Nonetheless, estimates were tallied to determine the level of emissions that would occur due to the proposed actions. On an annual basis, the project would result in nitrous oxide emissions exceeding the General Conformity threshold (100 tons/year) during operations. However, as stated earlier since Broward County is in an attainment area, there is no CAA requirement to meet this threshold or to mitigate for exceedance of it.

Rehydration of peat soils in the portion of WCA 3A north of Alligator Alley (approximately 70,000 hectares) is expected to stop the oxidation of peat soils by 2025 which releases between 3.71 and 9.2 tons of $C0_2$ per hectare per year. By 2065, rehydration should result in peat accretion which is estimated to capture approximate 3.7 tons of $C0_2$ per hectare per year (Richardson et. al., 2013). Peat accretion after 2065 will result in the sequestration of approximately 260,000 metric tons of $C0_2$ per year.

Table C.2.2-10. Air Quality Emissions for Major Project Features of ALT 4R2 During Operations.

Project Feature	Annual Emission Loads (Mton/yr)						Fuel Burnt	CO2
	CO	VOC	Nox	Sox	PM10	PM2.5	gallons/yr	Mtons/yr
A2 Inflow Pumping (G372, G370)	84	25	250	5	12	11	50,000	500
S356 Pump	28	8	83	2	4	4	17,000	170
Peat Accretion after year 2065*								(-260,000)

***Estimate of C02 sequestration from peat accretion is based on methodology found in Richardson et al, 2013.**

C.2.2.10.5 Without Project Air Emissions

The largest contributor of air emissions under the without project condition is the continued use of the 14,000 acre A-2 FEB lands for sugar cultivation. Sugarcane field burning is estimated to contribute 20 percent of the VOC, 48 percent of the PM2.5, 22 percent of the CO, and 11 percent of the NOx annual loads in Palm Beach County (Hall et. al 2010). **Table C.2.2-11** shows a rough estimate of the air emissions from sugar cane cultivation on the 14,400 acres A-2 FEB. Emissions for sugarcane cultivation were estimated using average heavy equipment emissions factors and an estimate of 16 gallons of diesel per acres of cultivation. Cane field burning factors were taken from Hall, et al (2010). Continued oxidation of peat soils will result in the release of as much as 51,500 tons of C02 from the A-2 FEB lands and 1,600,000 tons of C02 from northern WCA 3A.

Table C.2.2-11. Estimated Air Emissions From Continued Sugarcane Operations on A-2 FEB Lands and From Peat Loss in WCA-3A (North of Alligator Alley).

Activity	Annual Emission Loads (Mton/yr)						Fuel Burnt	CO2
	CO	VOC	Nox	Sox	PM10	PM2.5	gallons/yr	Mtons/yr
Sugar Cane Cultivation	10	3.5	20	.02	1.8	1.65	225000	2,250
Cane Field Burning	9	6				0.7		450
Peat Loss on A-2 Lands *								21,000 to 52,000
Peat Loss in WCA-3A (North of Alligator Alley) *								650,000 to 1,600,000

* Estimate of C02 Emissions from peat loss is based on methodology found in Richardson et. al 2013.

The total increases in air pollutants are relatively minor in relation to the existing point and nonpoint and mobile source emissions in Palm Beach, Broward, and Miami-Dade Counties. Impacts from project related emissions during construction and during the operational phase of CEPP would not significantly impact air quality within the airshed. Short-term loadings of internal-combustion engine exhaust gasses are expected to be negligible and not pose a threat to workers or local populations. The G-370 and G-372 pumps presently have air quality emissions permits. These permits may need modification to account for the additional operations and emissions. An air quality permit will be obtained prior to the construction of the S-356 pump station. Because the project is located within a designated attainment area, EPA's general conformity rule to implement Section 176 (c) of the Clean Air Act does not apply, and a conformity statement should not be required. Over the long-term, rehydration of peat soils in WCA 3A will capture many more tons of C02 than that emitted during construction or as a result of pump operations.

C.2.2.11 Hazardous, Toxic and Radioactive Waste

The FWO and with-project alternative conditions will have similar hazardous, toxic and radioactive waste (HTRW) conditions in the future with the exception of the lands used for the A-2 FEB. Under the FWO condition, the A-2 FEB lands will likely continue to be farmed which will result in the additional application of agricultural pesticides in the cultivated portions of this property and the inadvertent release of petroleum and pesticides in operation and maintenance areas. During the construction of project features, is possible that undiscovered HTRW contamination will be found. Per EC 1165-2-132, the non-federal sponsor will be required to remediate these sites at their sole expense. There is also the potential for HTRW release associated with the operation of project pump stations; however, with modern facilities and best management practices, this presents a minor risk to the environment.

C.2.2.11.1 Residual Agricultural Chemicals

The USACE HTRW policy (ER 1165-2-132) directs that Construction of Civil Works projects in HTRW-contaminated areas should be avoided where practicable. In September 2011, the ASA(CW) provided an exception to this HTRW policy for CERP Projects (Memorandum for Deputy Commanding General for Civil and Emergency Operations, Subject: Comprehensive Everglades Restoration Plan (CERP) – Residual Agricultural Chemicals, Dated September 14, 2011). A copy of this policy is included in **Appendix C.4.** If specific criteria are met, this policy memorandum allows residual agrichemicals to remain on project lands and allows the USACE or SFWMD to integrate response actions directly into the construction plan.

At the request of the SFWMD, this section of the PIR has been included in the CEPP PIR to comply with the ASA(CW) policy. A copy of the letter from the SFWMD requesting application of the policy is included in **Annex H** along with HTRW reports, sampling protocol, and correspondence.

The FDEP and USFWS have reviewed the sampling performed to date on the A-2 FEB land and preliminarily indicated that the soils do not require any remedial action in order to protect USFWS trust species. The FDEP and USFWS is recommending that additional sampling of water quality, periphyton and apple snails be conducted in lieu of requiring soil remediation since they believe that the risks to trust species are minimal. Development of an agrochemical best management practices (BMP) plan for the interim use of the property was also recommended. It is possible that in the future, some impacted soils may be identified for removal or isolation or the USACE may come in contract with these soils during construction. For these reasons, the SFWMD has requested that the CERP Residual Agricultural Chemical policy be applied to this project.

This section of the PIR partially fulfills the requirements established in the aforementioned policy for the A-2 FEB portion of the CEPP. The Jacksonville District is seeking conditional but not final approval of the application of the Ag-chem policy from HQ USACE at this time. Final approval will be requested prior to design of the A-2 FEB when it is expected that supplemental information will be available to completely fulfill the policy requirements. Pursuant to paragraph 4 of the policy and prior to beginning construction, the Jacksonville District will obtain written documentation of regulatory approval(s) for all response actions from SFWMD, and enter into an agreement with the SFWMD wherein the USACE accepts and expends funds, contributed by the SFWMD, for performance of the approved response action(s).

As part of the land acquisition process and in coordination with the Florida Department of Environmental Protection (FDEP) Bureau of Waste Cleanup and USFWS Contaminants Section, SFWMD assessed the A-2 FEB site in a series of Phase I/II Environmental Site Assessments (ESA) and Ecological Risk Assessments (ERA). The SFWMD performed point source remediation and completed multiple corrective actions in accordance with FDEP regulations. A Summary of the completed corrective actions performed by the SFWMD is included in the audit reports included in **Annex H**. The only chemicals of concern remaining on the A-2 FEB site are residual agricultural chemicals.

As required, the following is a discussion of each of the Policy Memorandum's requirements and conditions for only the constituents remaining on the A-2 FEB site. Documentation of full compliance with the CERP Ag-Chem policy requirements will be provided prior to construction on the A-2 FEB lands that have impacted soils.

a. Residual Agricultural Chemicals

1) Determination that lands were formerly cultivated soils. At the time of acquisition, the 14,408-acre site was in active sugar cane and rice cultivation. The historical research included in the Phase I/II ESA indicated that prior to converting the land to agricultural production around the 1950s, the land was undeveloped lowlands.

2) The nature and extent of residual agricultural chemicals within the cultivated area of the A-2 FEB lands was investigated by conducting soil sampling at 30 randomly selected 50-acre grids located within the 14,400 acre site. The 50-acre grid soil samples were analyzed for organochlorine pesticides (OCPs) by EPA method 8081, organophosphorus pesticides plus atrazine by EPA Method 8141, chlorinated herbicides by EPA Method 8151, and total organic carbon (TOC), and RCRA 8 metals

plus copper by EPA method 6010/7471. This list includes a total of 88 distinct analytes. **Table C.2.2-12** is a summary of the detected analytes found on the property. **Table C.2.2-12** lists all of the residual agricultural chemicals with the maximum concentration remaining on the A-2 FEB site as well as the applicable regulatory criteria for each detected chemical. Arsenic was detected in all samples at concentrations above the residential direct exposure criteria. Given that the project lands will be inundated, exceedance of residential exposure criteria does not pose a risk to human health. Atrazine was detected above the groundwater leachate limit on approximately 23 percent of the tested grid cells. Since atrazine is a modern, low-persistence herbicide this exceedance is classified as temporary and is expected to naturally attenuate once active sugar cane cultivation ceases.

Copper was detected on approximately 30 percent of the tested grids at concentrations that exceed the USFWS interim criteria of 85 mg/kg for copper in inundated soils/sediments. The estimated 95% Upper Confidence Limit concentration for A-2 FEB residual soil copper is estimated to be 81 mg/Kg which is slightly lower than the USFWS interim criterion. The 85 mg/kg criterion which is intended to protect the endangered Everglades snail kite, was established based upon sandy soil conditions associated with citrus cultivation. Relevant scientific literature reviewed as part of the Screening Level Ecological Risk Assessment (SLERA) performed on behalf of the SFWMD (PSI, 2013) indicate that the bioavailability of copper to ecological receptors is likely to be significantly lower in organic muck soils found within the A-2 FEB lands than it is for sandy citrus soils. Given that most of the samples exceeding 85 mg/Kg copper were in the 85 to 95 mg/ range and that the organic soil would make copper less available, PSI, the SFWMD contractor determined that the copper concentrations in the highly organic soils would not present a significant risk to the snail kite. The USFWS agreed with this assessment. Dieldrin, a legacy organo-chlorine pesticide was detected in 10 percent of the grid samples at concentrations that exceed the groundwater leachability criteria and the Sediment Quality Assessment Guideline Threshold Effect concentration (SQAG-TEC). Subsequent Synthetic Precipitation Leaching Procedure (SPLP) testing was conducted for the two (2) samples with the highest dieldrin concentrations. SPLP results indicated that dieldrin was not detected in either sample above the laboratory minimum detection limit (MDL); however, the MDL in this case was above the applicable surface water criteria. This is not uncommon since surface water criteria for organic chemicals are based on derived toxicity estimates and are not set with consideration for achievable laboratory detection limits. In this case, surface water flows and rainfall are expected to dilute the dieldrin from the sediments sufficiently such that surface water quality criteria will be met. After reviewing the analytical data, the USFWS and FDEP concurred that the detected concentrations of copper and other contaminants are unlikely to pose risk to trust resources or otherwise require remedial actions. The USFWS and FDEP agreed with the SFWMD's recommendation that sampling for detected pesticides and metals be performed during start up of the A-2 FEB. Copies of the USFWS and FDEP correspondence are found in **Annex H.**

Table C.2.2-12. Residual Agricultural Chemicals Detected on A-2 FEB Lands During January 2013 Sampling of Cultivated Lands (PSI, 2013).

				Regulatory Limits (mg/Kg)				
Parameter	CAS #'s[1]	CERCLA[2] Regulated (Y/N)	Range[3] Observed (mg/Kg)	EPA Regulatory Limits[4] (mg/Kg)	SCTL-CDE[5]	SCTL-RDE[6]	SQAG-PEC[7]	SQAG-TEC[8]
Arsenic	7440-38-2	Y	3.1-6.8	1.6	12	2.1	33	9.8
Barium	7440-39-3	Y	69-110	190,000	130,000	120	60	20
Cadmium	7440-43-9	Y	<0.1 - 0.18	800	1,700	82	5.0	1.0
Chromium	7440-47-3	Y	5.6-28	NG	470	210	110	43
Copper	7440-50-8	Y	53-110	41,000	89,000	150	150	32/85[9]
Lead	7439-92-1	Y	4.7-8.4	800	1,400	400	130	36
Mercury	7439-97-6	Y	0.077-0.15	43	17	3	1.1	0.18
Selenium	7782-49-2	Y	<0.58 - 3.7	5,100	11,000	440	N/A	4.2[10]
Silver	7440-22-4	Y	<0.3 - 0.64	5,100	8,200	410	2.2	1.0
2,4-D	94-75-7	N	<0.057-0.94	7700	13,000	770	***	***
Atrazine	1912-24-9	N	<0.025 - 3.5	7.5	19	4	NG	0.0003
Metribuzin	21087-64-9	N	<0.018 - 1.7	15,000	290	54	***	***
Phorate	298-02-2	N	<0.0036 - 0.12	120	320	16	***	***
Dieldrin	60-57-1	Y	<0.00099 - 0.0051	0.11	0.3	0.06	0.062	0.0019

Notes:
mg/Kg - milligrams per Kilogram
NG - No guideline
- Site concentrations for carcinogenic polycyclic aromatic hydrocarbons must be converted to Benzo(a)pyrene equivalents before comparison with the appropriate direct exposure SCTL for Benzo(a)pyrene using the approach described in the February 2005 'Final Technical Report: Development of Cleanup Target Levels (CTLs) for Chapter 62-777, F.A.C.'
[1]CAS Registry Number (CAS#'s) - unique numeric identifier which designates one substance and has no chemical significance.
[2]40 Code of Federal Regulations (CFR) 302.4, Designation of Hazardous Substances - Comprehensive Environmental Response, Compensation, Liability Act
[3]Range of chemical concentrations observed in all the samples collected within the Agricultural Areas only.
[4]USEPA - Regional Screening Levels (RSL) for Chemical Contaminants at Superfund Sites - Industrial Soil
[5]Chapter 62-777, FAC, Table 2 - Technical Background Document, SCTLs, Direct Exposure - Commercial / Industrial
[6]Chapter 62-777, FAC, Table 2 - Technical Background Document, SCTLs, Direct Exposure - Residential
[7]Development and Evaluation of Sediment Quality Assessment Guidelines, Volumes 1-4 (MacDonald, 2000), Sediment Quality Assessment Guidelines-Probable Effects Concentration
[8]Development and Evaluation of Sediment Quality Assessment Guidelines, Volumes 1-4 (MacDonald, 2000), Sediment Quality Assessment Guidelines-Threshold Effects Concentration
9USFWS Interim Screening Level for Everglades Snail Kite
10No SQAG criteria have been developed for selenium. An Action Level of 4.2 mg/kg was negotiated with USFWS on the C9/C11 project for Selenium in organic soils.

3) Determination that agricultural chemicals were commercially available products, lawfully applied for their intended purpose, not spilled, and did not result from waste management.

Phase I/II ESA were conducted on the site using an environmental protocol approved by SFWMD, FWS and FDEP-Bureau of Waste Cleanup. (Copies of summary environmental audit report and the environmental protocol are included in **Annex H.**) These Phase I/II audits document long-term sugar cane farming activities that began in the 1960's. **Table C.2.2-12** lists the chemical compounds found on the project lands that exceed regulatory limits or guidelines. These compounds are either active ingredients found in commercially available products registered under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) (7 U.S.C. 136a) or they are micro-nutrients that are added to increase the fertility of muck soils utilized to grow sugar cane (Rice, et al, 2010).

Copper was found in 30 percent of the soil samples above 85 mg/kg. The average copper soil concentration was 76.8 mg/kg. The minimum concentration was 53 mg/kg and the maximum copper concentration was 110 mg/kg. The average concentration was compared to potential residual concentrations that result from long-term application at recommended rates. If one assumes 40 years of copper application at a rate of 2 lb/acre/year (Rice, 2010), and a background of 30 mg/Kg, the potential average concentration of copper distributed in the top 1 ft of soil would be

approximately 90 mg/Kg. That the measured average is somewhat lower can be accounted for by losses to deeper soils or use of less copper in some areas. For comparison, copper concentrations on industrial National Priority List sites where spills or disposal have occurred are typically are in the 1,000s of mg/Kg.

Arsenic has a long and continued history of use in agriculture. It is likely that the reported arsenic concentrations found on the A-2 FEB land (average of 4.5 mg/kg) are the result of a combination of background arsenic (0.8 to 3.7 mg/Kg, per Chen 2001) and arsenic added during agricultural operations.

Lead was found at concentrations above the residential exposure limit (RDLE); however, since the A-2 FEB land will be inundated this particular criteria is not relevant.

Elevated selenium concentrations have been found on previously farmed land in Miami-Dade and Broward counties. Residual selenium concentrations in farm soils in South Florida are attributed to trace selenium contained within fertilizers applied to farms to enhance fertility.

Dieldrin and Atrazine are pesticides and herbicides that are or were registered under FIFRA. Their presence on the A-2 FEB lands is not unusual for farmed soils in the EAA.

The exceedances for barium, cadmium, chromium, mercury, and silver were of the SQAG limits which are guidelines but not promulgated standards. Several pesticides were detected (2,4, D , metribuzin, and phorate; however, the concentrations were below applicable standards and no SQAG limits exist for these contaminants.

Given the information presented here and other site evidence, there is no indication that the concentrations found on the A-2 FEB cultivated lands are indicative of a spill, deliberate on-site disposal or some other non-farming activity. A reasonable conclusion regarding the source of these residual soil contaminants is that they are the result of routine application of chemicals to the fields during routine farming operations.

4) Availability of Alternative Lands (why avoidance of land was not practicable). Much of the land in south Florida that is not currently residential, commercial, or industrial was once used for agriculture, even including some areas that now comprise the Everglades National Park. There are few open areas that were not used for agriculture. The lands for the A-2 FEB components were required to be located in the EAA Miami Canal Sub-basin with access to the Miami Canal on approximately 10,000 to 14,000 acres of land. There are several possible sites. The existing land use for these sites was predominantly sugar cane, turf grass, other agriculture or wetlands. Other than using other agricultural lands in the sub-basin, the A-2 FEB facility could be sited in wetlands. Siting storage facilities on wetlands obviously involves adverse impact to wetland habitat. In terms of the potential for presence of problematic concentrations of residual agricultural chemicals, sugar cane lands are considered to be lower risk than turf grass, citrus, or truck crop lands since persistent organo-chlorine pesticides were generally not applied at high rates during sugar cane cultivation.

5) Project Purpose (conversion from agricultural production to an aquatic restoration purpose). The project purpose for the A-2 FEB is capture and store releases from Lake Okeechobee and then distribute the water to STA3/4 and Compartment B of STA2 for treatment prior to releasing this water into northern WCA 3A. The project will inundate the land with water for an extended period of

time in order to meet federal project goals. This purpose is achieved with a 14,000 acre (wetted area) reservoir which will be inundated with up to 4 feet of water. Therefore, these components require the land conversion from agricultural production to aquatic restoration which inundates the land with water in order to meet the Federal project goals.

b. Regulatory Coordination

The SFWMD has conducted several Phase I/II site assessments prior to and since acquiring the A-2 FEB lands in 1999. A discussion of the findings of these investigations and coordination of remedial activities with FDEP in included in the Summary Environmental Report, PSI, Inc, August 21, 2012 which is in **Annex H**. In January of 2013, the SFWMD conducted additional sampling of cultivated areas on the A-2 FEB lands. The USFWS and FDEP have preliminarily determined that the residual agricultural chemicals found on the A-2 FEB lands do not present a risk to protected resources. Based on the results of the 2013 soil testing, the USFWS and FDEP are recommending that during the initial operations of the FEB, the SFWMD perform testing of water for several contaminants (2,4, D, atrazine, metribuzin, phorate, dieldrin, chromium, mercury, selenium, copper) as well as testing of periphyton and apple snails for copper.

The FDEP also reviewed the 2013 soil sampling results and recommended the development of a soil management plan to address the fate of arsenic impacted soils during construction as well as the same start-up operations sampling program as provided by the USFWS. The FDEP and the USFWS both recommended that agrochemical best management practices be instituted during the continued cultivation of the lands.

The USFWS and FDEP review letters did not identify threshold concentrations or the potential consequences of detecting elevated concentrations of copper in water, periphyton, or apple snails during initial operations monitoring. The USFWS and FDEP provided the same comments on the A-1 FEB which has similar levels of copper in the cultivated soil. To better define threshold copper concentrations, the SFWMD has jointly sponsored several studies which are currently underway to evaluate copper bioaccumulation, toxicity, desorption, and other important parameters that significantly impact the potential risks associated with exposure of the Everglades snail kite, and other species to copper in sediments. The SFWMD believes that they will be in a better position to discuss threshold concentrations with the USFWS and FDEP after completion of these studies within the next 12-18 months, and prior to the A-1 FEB construction. The risk that threshold copper concentrations detected in the A-2 FEB during start-up operations will result in a post-construction remedial action requirements is minimal given completion of ongoing copper bioaccumulation studies and because the operation of the A-1 FEB will precede the A-2 FEB design/construction by several years.

The A-2 FEB site was purchased with Farm Bill monies and per the Framework Agreement between the DOI, DOA, DEP and SFWMD, a subsequent protocol strictly controls the use of agricultural chemicals on leased lands to a predetermined list unless specifically approved by the FWS. The A-2 lands will remain in agricultural production for several years until the A-2 project feature is set for construction at which time the agricultural leases will be terminated. Once farming has ceased on the A2 FEB project lands, an Exit Assessment will be performed to determine the presence of any new potential sources of HTRW since the completion of the previous Phase II ESA, and to verify the concentration of contaminants in the cultivated areas at selected locations. The results of these audits will be provided to the FDEP and USFWS for their review, comment, and concurrence regarding the need for remedial actions.

c. Soils Removed

Testing and Investigations Performed. The environmental site assessments for the A-2 FEB site generally followed the FDEP and FWS established protocols in terms of procedures with the exception that 10 percent of the 50-acre grids were sampled rather than the normal 30 to 50 percent of the grids. The lower sampling rate was acceptable to the USFWS because of the prior land use which was limited to sugar cane cultivation in the cultivated areas and because the sampling results showed similar concentrations of detected analytes rather than widespread differences between sampled grids. The testing and investigations performed during the Phase I/II concluded that the remaining residual agricultural chemicals on the A-2 FEB site are either not "listed" hazardous wastes or are at concentrations reflecting lawful application for its intended purpose, and was not the result of a spill or waste management.

Hazardous Waste Characteristics. Per Subpart C (40 CFR 261.20 et seq.) the four RCRA characteristics of hazardous waste are: ignitability, corrosivity, reactivity, and toxicity. Ignitable wastes readily catch fire, sustain combustion, and when ignited, burn so vigorously and persistently that it creates a hazard. Corrosive wastes are a liquid and are acidic or alkaline wastes that readily corrode or dissolve flesh, metal, or other materials. Reactive wastes are unstable, readily explode or undergo violent reactions.

None of the soils tested in 2013 on the A-2 FEB site exhibit any of these hazardous waste characteristics. Per **Table C.2.2-12**, the concentrations of the remaining residual agricultural chemicals are not sufficient to render the soils ignitable or reactive. FDEP-Bureau of Waste Cleanup required no special handling of similarly impacted soils at other CERP project sites. Also, cultivation of crops in these and similar soils in the region is not known to result in soil combustion or explosion. Similarly, no corrosive materials are known to be present. To be corrosive, materials must be in a liquid state. Soils on the site are solids. Therefore, testing for these three characteristics (ignitability, corrosivity, and reactivity) is not necessary.

The fourth characteristic is toxicity. Toxic wastes leach toxic compounds or elements into underlying soils or groundwater supplies. For a toxic constituent in 40 CFR 261, Subpart C, demonstration of the RCRA toxicity characteristics can be determined by utilizing the Toxicity Characteristics Leachate Procedure (TCLP) test or by analyzing for total constituent concentration and applying the "Rule of 20" to infer whether the RCRA Toxicity Characteristics regulatory limits would be exceeded. The "Rule of 20" allows a toxicity determination to be made by comparing the total concentration analysis (dry weight) to the TCLP regulatory concentration (wet weight). The rule is used by multiplying the RCRA TCLP limit (mg/l) by 20 and then comparing this value to the measured total constituent concentration (mg/kg). If the measured total constituent concentration value is less than the TCLP concentration multiplied by 20, the material does not exhibit RCRA characteristics based on toxicity as determined by analytical procedures. Additionally, if the constituent is not listed in Table 1 of Subpart C, the material is not a RCRA characteristic waste based on toxicity.

Table C.2.2-13 summarizes the results of the "Rule of 20" for the residual agricultural chemicals on the A-2 FEB site. Based on the "Rule of 20" none of the remaining soils containing residual agricultural chemicals on the A-2 FEB site exceed the RCRA characteristic toxicity levels. Based on the information provided by the SFWMD, the USACE concurs that none of the remaining soils on

site will need to be removed from the A-2 FEB site by SFWMD prior to the start of construction based on the criteria in the Policy Memorandum (Soils Removed). Should soils containing residual agricultural chemicals be found to contain contamination that rises to a RCRA level before, during or after construction, the NFS shall remove, properly dispose, and manage such soils at 100% NFS cost and USACE shall not conduct such work. As discussed in previous sections, after agricultural operations have ceased on the lands, subsequent testing will be performed and the results subjected to the RCRA hazardous waste determination to ascertain compliance with the USACE Policy for Agricultural Chemicals on CERP lands

Table C.2.2-13. "Rule of 20" Test for Residual Soil Contaminants Found on A-2 FEB Lands.

Agricultural Chemicals on site	Maximum Concentration (mg/kg)	RCRA TCLP Concentration (mg/l)	RCRA TCLP Concentration multiplied by 20 (mg/kg)	Is Max Concentration Less than TCLP times 20?
Arsenic	6.8	1.0	20.0	Yes
Atrazine	0.0035	Not Listed	Not Applicable	Not Applicable
Barium	110	100	2000	Yes
Cadmium	0.18	1.0	20	Yes
Chromium	28	5.0	100	Yes
Copper	110	Not Listed	Not Applicable	Not Applicable
Dieldrin	0.0045	Not Listed	Not Applicable	Not Applicable
Mercury	0.15	.2	4.0	Yes
Metribuzin	1.7	Not Listed	Not Applicable	Not Applicable
Phorate	0.12	Not Listed	Not Applicable	Not Applicable
Selenium	3	1	20	Yes
Silver	0.64	5.0	100	Yes
2,4-D	3	10	200	Yes

d. Cost Comparison for Soils Containing Residual Agricultural Chemicals Remaining on Project Lands

The FDEP and USFWS have preliminarily determined that the residual agricultural chemicals found on the A-2 FEB lands do not present a risk to protected resources. At this time, the FDEP and USFWS are recommending that the SFWMD perform testing of water, periphyton algae, and apple snails for copper during the initial operations period for the FEB. Given that the USFWS has not identified soils requiring removal, no costs can be identified at this time. If the USFWS determines in the future that some A-2 FEB project soils have to be removed or isolated, a cost comparison will be prepared.

e. Cost Comparison for USACE Acting as the Construction Agency and Performing the Response Action for the NFS

If the FDEP and/or USFWS determine in the future that some A-2 FEB project soils have to be removed or isolated, this cost comparison will be prepared as part of complying with the CERP Agricultural-Chemical Policy.

Cost effective analyses for determining if it is cost effective for the USACE to perform the non-RCRA response actions for the SFWMD will be prepared for the A-2 FEB if and when sufficient information is available. The assumptions used to develop the costs for the construction scenario, where the USACE does not touch impacted soil, will likely be: 1) the SFWMD performs all earth moving construction activities that involve excavating impacted soils, stockpiling impacted soils, blending impacted soils, and placing blended materials; 2) the USACE performs construction actions such as pump foundation excavation of clean limerock, pump station construction, culvert installation, and earth moving construction in areas where impacted soils have either been removed or are covered with a minimum of 6 inches of clean fill; 3) splitting the work between the two agencies does not result in additional costs associated with actual construction activities, i.e., no additional material handling occurs; and 4) the additional cost of having two construction agencies and two contracts, results in an increase in the total amount required for design/engineering and contract supervision/administration. This assessment will be prepared and submitted to HQUSACE for concurrence prior to construction by USACE.

f. Engineering and Other Risks

1) Engineering Risk. The USACE will address risks during design and construction of the project components by: 1) Regulatory review of plans and specifications by the FDEP which is the delegated RCRA authority in Florida; 2) Review of environmental audits and environmental risk assessments prepared for and by the USFWS for potential impacts to Threatened and Endangered Species; 3) Incorporation of appropriate safety and handling specifications into the project bid documents; 4) Review of plans and specifications by the USACE Environmental and Munitions Center for Expertise (EM CX) prior to contract advertisement; 5) Conducting appropriate supervision and oversight of construction; 6) Conducting confirmation sampling after feature construction, and 7) SFWMD's obtaining final approval of construction actions by FDEP. These safeguards further reduce the risk of future releases or exposure and are consistent with USACE construction standards and requirements.

2) Other Risk. Once constructed, it is possible that man-made actions might disturb the soils containing residual agricultural chemicals if such material is placed within the project features or otherwise remains on the project site. To limit this risk, land use restriction covenants may be incorporated into the property deeds where required by FDEP. The SFWMD shall ensure that land use restrictions if any will not reduce ecosystem restoration benefits, hinder O&M, or interfere with the Project's proper function. Once an approved soil management plan is available, CESAJ environmental specialists and the EMCX (Environmental and Munitions Center of Expertise) will review the plan to determine other risks if any. The results of the CESAJ and EMCX review will be provided to HQUSACE for concurrence.

3) Final Risk Determination. The USACE and SFWMD will prepare a final determination report for the A-2 FEB to confirm that the overall project risk from impacted soils is low and acceptable. The final determination report will be submitted to HQUSACE prior to construction. For each construction contract managed by the USACE, the SFWMD will be responsible for providing full funding to the USACE prior to contract advertisement for the identified contract specific cost of addressing residual agricultural chemicals.

g. **NFS Responsibility:**
The NFS is 100% responsible for the cost of actions taken due to the presence of residual agricultural chemicals, at no expense to the Federal Government. Any future costs associated with the presence of residual agricultural chemicals at the Federal project site are a 100% NFS cost and responsibility. The costs for characterization of the project lands in preparation for conducting a response action for the residual agricultural chemicals and removal of soils that are hazardous waste shall be included as 100% NFS responsibility. The Jacksonville District shall not conduct actions to address residual agricultural chemicals for the SFWMD during the operation and maintenance, repair, replacement and rehabilitation (OMRR&R) phase of the project.

C.2.2.12 Noise

Features of Alts 4R and 4R2 are the same. There would be minor, short term and less than significant increases in noise during construction of Alts 4R and 4R2. Alts 4R and 4R2 propose additional pump stations which would result in long-term, localized increases in noise. Alts 4R and 4R2 each add the fewest number of pump stations (two) over the other action alternatives, having the least effect on noise.

C.2.2.13 Aesthetics

Features of Alts 4R and 4R2 are the same. During construction of all features there would be a temporary short-term significant adverse impacts to aesthetic values in the construction areas. Alternatives 4R and 4R2 show a significant increase in aesthetic value over the FWO due to restoration of hydropatterns and sheetflow throughout the project area and provide minor beneficial effect. The restoration of sheetflow provides additional habitat for native plants and animals and opportunities for wildlife viewing.

There would be negligible and less than significant effects due to Alts 4R and 4R2 in Lake Okeechobee. In the Northern Estuaries, Alts 4R and 4R2 increased the aesthetic value due to decreased high flow events, providing minor beneficial effects. Reductions in high volume discharges to the estuaries would result in lower suspended solids, increased water clarity and the correct salinity envelope that maintain healthy SAV beds. These benefits could also lead to an increase in wildlife viewing opportunities (Orth et al., 2006). Within the EAA, the existing aesthetic character of the A-2 footprint is similar to the EAA as a whole; the landscape is flat and has a predominantly uniform and organized appearance. Wetland vegetation is anticipated to colonize the proposed A-2 FEB increasing wildlife utilization and opportunities for wildlife viewing within the area in Alts 4R and 4R2, thus providing minor beneficial effects. In the southern estuaries Alts 4R and 4R2 increase the aesthetic value due to an increase in native plants and animals due to increased flows in Florida Bay providing increase in potential wildlife viewing as well as providing a potential for the reduction in red tide occurrences.

Within the Greater Everglades, Alts 4R and 4R2 have a greater potential effect on aesthetics compared with FWO due to the construction of a new levee (Blue Shanty Levee). There would be temporary, short-term, localized adverse effects to aesthetics during construction of the proposed features. Alternatives 4R and 4R2 show a minor beneficial effect in aesthetic value over the FWO due to restoration of hydropatterns and sheetflow throughout the project area. The restoration of sheetflow provides additional habitat for native plants and animals and increased opportunities for wildlife viewing. Restoration of flows within Florida Bay and the southwestern coastal estuaries that reduce extreme salinity ranges improves habitat within these regions, increase potential opportunities for wildlife viewing. Alternatives 4R and 4R2 include backfilling the Miami Canal from 1.5 miles south of S-8 down to Interstate 75, there-

by improving aesthetics due to removal of this unnatural landscape feature, providing long-term minor beneficial effects.

The complete degradation of the L-67 Extension levee provides a long-term minor beneficial effect in aesthetics due to the restoration of sheetflow increased native plants and animals and viewing potential. The construction of the Blue Shanty Levee (~8 mile levee) in WCA 3B has a minor adverse effect on aesthetic value due to the addition of a levee within a wetland, however, it creates a flowway to the west that provides wildlife viewing opportunities and water flowing under Tamiami Trail. The seepage barrier in Alts 4R and 4R2 provides a significant and moderate negative effect to the aesthetics.

C.2.2.14 Socioeconomics

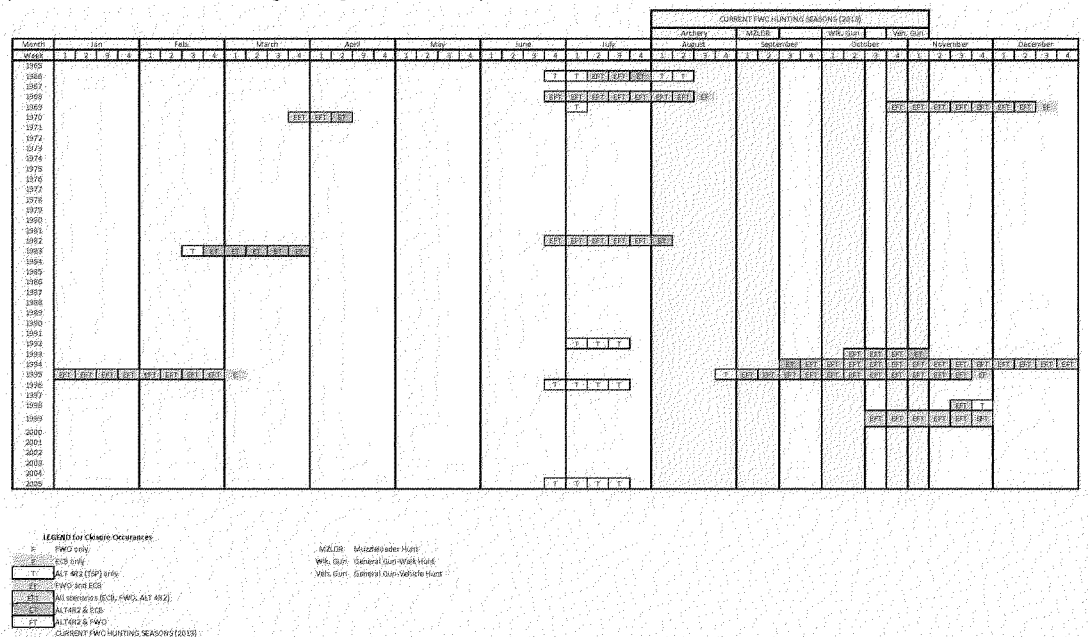
Effects are provided in the main report in **Section 5.2.15**.

C.2.2.15 Recreation

In Lake Okeechobee and the Northern Estuaries, FWO and Alts 4R and 4R2 have a negligible and less than significant effect on current recreation opportunities. . There will be no impacts to recreational navigation with this project. Alternatives 4R and 4R2 may provide enhanced fishing opportunities due to better salinity conditions in the Caloosahatchee and St. Lucie Estuaries. In the Everglades Agricultural Area (EAA), currently no recreation exists on the project site so Alts 4R and 4R2 would be positive for public access meeting the identified needs according to Florida's Statewide Comprehensive Outdoor Recreation Plan (SCORP) compared to FWO.

In the Greater Everglades, in the FWO condition recreational fishing would be affected little if at all. Hiking, biking and camping will not be affected directly. In the FWO any changes in recreation would be due to degraded quality of wetlands and the aesthetic values that could decrease as wildlife viewing and nature study would be degraded. Alternative 4R and 4R2 effects to recreation will be negative or positive depending on the activity and location. The Blue Shanty Levee will bisect L-67C. Recreational fishing by prop boat to the northern end of L67C canal would continue to be available from a new public boat ramp located in the northern end of L67C at the S151, providing minor beneficial effect. Also at the S151 a new public boat ramp will allow access into the northern 5 miles of the Miami Canal south of S151 not previously served by a public boat ramp. Recreational fishing by boat will have a significant and major adverse effect by back filling the Miami canal. This affects 13.5 of the 33 miles of the Miami canal in WCA 3. Bank fishing opportunities could have a minor beneficial effect by the addition of access points around proposed structures. Terrestrial mammal hunting (deer, hog, rabbit, etc.) could have a short-term significant, adverse and unavoidable effect by increased hydration in areas that have been drier. In the long term if not better hydration peat loss to oxidation and fire would degrade current habitat further. **Table C.2.2-14** compares alternatives, showing when high water would have prompted FWC to evaluate WCA 3 for a high water closure. The table uses the current closure criteria to compare alternatives, and does not replicate history or forecast FWC decisions. Waterfowl hunting should improve with better hydration throughout the greater everglades during the early part of the dry season. Bird watching should improve with increased hydration of the Greater Everglades as well. Improved access and designation of blue and greenway trails will be positive. In the Southern Estuaries there is no effect on recreation with the FWO. For Alts 4R and 4R2 access to the Southern Estuaries would not change based on CEPP, however, impacts to existing quality of recreation can be impacted negatively or positively depending on location and changes to fish habitat as identified above for the Greater Everglades, however additional flows to Florida Bay are expected to provide enhanced fishing opportunities, providing a minor beneficial effect. A Recreation Plan is included in **Appendix F**.

Table C.2.2-14. Weeks with High Water Closures for ECB, FWO, and Alt4R2 Comparisons with Existing Hunting Seasons Displayed for WCA 3 (WCA 3A-2 and WCA 3A-3 Two Gauge Average >= 11.60' NGVD). Blank cells mean there were no closures.



C.2.2.16 Land Use

C.2.2.16.1 Wetlands and Uplands

Much of the future development within the study area is expected to occur on lands that were formerly in agricultural use. **Table C.2.2-15** summarizes the impacts to wetlands and uplands for Alts 4R and 4R2. Features of Alts 4R and 4R2 are the same. Alternatives 4R and 4R2 each show a significant and major beneficial effect with an increase of 625 acres of wetland/upland habitat over the FWO as well as an increase in wetland function. While there are some minor adverse effects due to the construction of some features, most notably the Blue Shanty Levee in WCA 3B, the construction of other features, the degradation of levees and the backfilling of canals reconnects and adds wetland acreage and provides the needed topography for sheetflow to restore the natural system. Alternatives 4R and 4R2 each shift approximately 13,800 acres of agricultural land use with wetland soils to a higher quality wetland with the construction of the A-2 FEB. The A-2 FEB would alter the land use from agriculture to an FEB that includes wetland habitat. The degradation of the L-4 levee adds approximately 35 acres for each Alt due to the degradation of that levee and the reconnection of the wetlands in northwestern WCA 3A. The backfilling of the Miami Canal would provide an additional 417 acres of wetlands for each Alt. The backfilling of the Miami Canal would restore the wetland habitat and reestablish sheetflow in northern WCA 3. Spoil mounds on both sides of the Miami Canal from S-8 to S-339 would be removed and 22 spoil mounds (the highest priority/highest functioning Florida Fish and Wildlife Conservation Commission (FWC) enhanced spoil mounds) would be maintained for each Alt while the others would be removed. In addition to the removal of the selected spoil mounds in order to promote sheetflow across the backfilled Miami Canal, additional mounds (1.5 feet above the marsh surface) would be created every mile for each Alt from S-8 to Interstate 75 to prevent hydraulic channelizing and flow and provide upland animal habitat. This would provide an additional 45 acres of upland habitat for each Alternative. This additional upland habitat provides refuge for terrestrial mammals during periods of high water and a minor beneficial effect. These mounds also align with the historic ridge habitat and there is the possibility that the placement of the mounds would help reestablish the ridge and slough pattern in WCA 3A.

In southern WCA 3A and WCA 3B several features increase wetland habitat while other features remove/impact wetland habitat while connecting WCA 3A to WCA 3B and ENP. The proposed L-67A culverts would have a minor adverse effect to the wetland of 4.5 acres/gated culvert for each Alt. Alternatives 4R and 4R.2 each have 3 culverts, thus a loss of 13.5 acres for each Alt. However, the culverts are critical to connecting WCA 3A and WCA 3B and in conjunction with the gated culverts in L-67A levee, there are 6,000 foot gaps in the L-67C levee that would increase wetland habitat. Each 6,000 foot gap would provide an additional 9 acres of wetland habitat; therefore Alts 4R and 4R2 would each provide 9 additional acres of wetlands. Alternatives 4R and 4R2 each have only one 6,000 foot gap because the other 2 gated culverts are included in the Blue Shanty flowway discussed below. The degradation of approximately 8 miles of the L-67C in Alts 4R and 4R2 provide 64 acres of additional wetlands for each Alt. The degradation of the L-29 levee provides an additional 46 acres of wetlands for each Alt (approximately 4.3 miles of degradation per Alt). The construction of the Blue Shanty Levee to create the flow way between WCA 3B and ENP removes 84 acres of wetlands in WCA 3B for each Alt (approximately 6.25 mile levee per Alt). In ENP, the backfill of the entire L-67 Extension canal provides an additional 104 acres of wetlands for each Alt.

In addition to the benefit of increased wetland/upland acres, the wetland function increases as well due to the backfilling of the Miami Canal and the restoration of sheetflow across WCA 3A and 3B into ENP. The initial construction may have a temporary adverse affect on the wetland function in the construc-

tion areas, but once the project is complete, all alternatives would increase wetland function based on the acres of wetlands gained.

Table C.2.2-15. Wetland and upland impact of the project area.

Project Feature	FWO Acres of Wetland Gain (Loss)	Alt 4R Acres of Wetland Gain (Loss) over FWO	Alt 4R2 Acres of Wetland Gain (Loss) over FWO
L-4 Degrade	0	35	35
Miami Canal Backfill	0	417	417
Miami Canal Spoil Mounds	0	45	45
L-67A Culverts	0	(13.5)	(13.5)
L-67C Gaps	0	9	9
L-67C Flow Way Degrade	0	64	64
L-29 Degrade	0	46	46
Blue Shanty Levee	0	(113)	(113)
L-67 Extension Backfill	0	104	104
Old Tamiami Trail Road Degrade	0	31	31
Total Net Change	**0**	**625**	**625**

C.2.2.16.2 Agriculture

The entire CEPP project area consists of lands currently under public ownership. 14,000 acres in the proposed A-2 FEB footprint are currently in production for sugar cane. Alternatives 4R and 4R2 would convert 14,000 acres of agricultural lands to wetlands due to the construction of the proposed A-2 FEB. As described in **Section 5.2.1.7**, Hydrology, negligible changes were noted for water stages within the SDCS; therefore no indirect effects to agriculture within this region are anticipated. Coordination with the United States Department of Agriculture (USDA) and National Resources Conservation Service (NRCS) to meet the requirements of the Farmland Protection Policy Act, is ongoing. When detailed design information that locates each of the plan components is completed, it can then be determined how many acres of unique farmland would be affected by the Project. (Refer to **Appendix C.4.12**).

C.2.2.17 Cultural Resources

The Everglades and associated ecosystems are a nationally significant resource and have been severely impacted by human activities for over a hundred years primarily through drainage practices and agriculture. A review of the Florida State Master Site Files (FMSF) indicate that there are 23,499 recorded cultural resource sites and resource groups within the CEPP study area that have a survey determination and/or State of Florida Historic Preservation Office (SHPO) evaluation of other than ineligible for listing with the National Register of Historic Places (NRHP). For this document, the use of the term cultural resources includes significant historic properties that are determined eligible or potentially eligible for NRHP listing, and culturally significant sites. See **Section 10** in the Main Document for definitions of terms.

Consultation in conjunction with the National Historic Preservation Act (NHPA) was initiated with the Seminole Tribe of Florida's Tribal Historic Preservation Office (THPO), the Miccosukee Tribe of Indians of Florida's NAGPRA Representative, the SHPO, Everglades National Park, Chief of Cultural Resources (ENP) and Florida Bureau of Archaeological Research. During formal consultation, a number of conclusions were drawn: 1. It was determined that additional surveys were needed to identify cultural resources within specific areas of potential effect. 2. It was also decided that as the CEPP project progressed, additional surveys may be needed, specifically during the Pre-construction, Engineering and Design (PED) phase, when designs were finalized and construction staging areas were determined. 3. Section 106 compliance with the NHPA would be conducted separately from NEPA and would not be completed during the current feasibility phase of the project, however would be complete prior to construction. See **Appendix C.5** for correspondence and/or consultation information regarding cultural resources within the project area.

This PIR/EIS meets cultural resources requirements as specified under NEPA. The CEPP will remain in compliance with the NHPA pre and post construction.

Area of Potential Effect

The area of potential effect (APE) for cultural resources differs greatly from the overall CEPP study area. For this project, the APE for cultural resources include the EAA A-2 footprint, portions of the L-6 levee and associated borrow canal, the L-5 canal, the S-8 Pump Station Complex, portions of the L-4 levee and associated canal, the L-28 Triangle, portions of the Seminole Tribe of Florida's Big Cypress Reservation immediately west of L-28 and north of I-75, portions of the Miami Canal, WCA 3A and 3B, L-67A and L67C levee, portions of the L-29 levee, the L-67 Ext levee and associated canal, portions of the Old Tamiami Trail, and portions of the L-31N levee, and Everglades National Park. Refer to **Appendix C.1.1.16** for a summary of the types and quantity of known cultural resources located within the study area versus the APE (see **Table C-1.8** in **Appendix C.1.1.16**).

Evaluation Criteria Specific to Cultural Resources

Impacts to cultural resources vary by individual components within Alts 4R and 4R2. Therefore, impact evaluations were based on a review of the individual components of each Alt to determine if actions would potentially result in impacts to significant cultural resources (which include sites eligible or potentially eligible for NRHP listing), described below. Avoidance of adverse effects to cultural resources is the Corps preference, therefore, throughout the planning process for CEPP, the project archaeologist, engineers, and plan formulators have worked closely to determine alternatives and features of alternatives that reduce or eliminate impacts to cultural resources. Pursuant to 36 CFR 800.1, where possible, the project design will be modified to avoid impacting significant historic properties and culturally significant sites. Where avoidance is not possible, other mitigation measures will be considered, which could include but are not limited to data recovery excavations. The mitigation measures will be developed in consultation with SHPO, tribal groups and other interested parties as established in implementing regulations for Section 106 of the NHPA.

The following significance thresholds have been used in determining whether components proposed for each Alt would result in a significant impact to cultural resources. The use of the term cultural resources includes historic properties eligible or potentially eligible for NRHP listing and culturally significant sites. A cultural resource impact is considered significant if implementation of a component of an Alt would result in any of the following when compared to FWO:

- Result in a change in the significance or eligibility for NRHP, including but not limited to any contributing elements, of a historical resource.

- Result in an adverse change in the significance or eligibility for NRHP of a historic resource.
- Disturb any human remains, including but not limited to those outside of formal cemeteries*
- Disturb memorials determined to hold public significance regardless of age.
- Result in adverse changes to sites identified through consultation with the Seminole Tribe of Florida and/or the Miccosukee Tribe of Indians of Florida as having cultural significance.

* The Corps is currently drafting a policy guidance memorandum to update and expand the 2008 CERP Policy on Human Remains that currently applies to the CEPP study area, to apply to all Civil Works and Regulatory actions within the respective jurisdiction of these Jacksonville District programs in the state of Florida. This document is an internal guidance memorandum designed to consolidate and clarify existing Coprs documents regarding the treatment of human remains pursuant to Section 106 of the NHPA and the Jacksonville District's Federal Trust Responsibilities for the state of Florida.

Comparison of Proposed Action Alternatives 4R and 4R2 and Future Without Conditions

The project schedule (**Section 6.7 and 6.11.2.3**) allows for a phased approach to Section 106 compliance, in that each suite of features will be consulted on as they arise. This will ensure that the most up to date information will be considered in the determination of effect. Also, based on final designs or modifications of the project features, additional work may be required for compliance with the NHPA. *While the Corps is currently in compliance with the procedural requirements of the NHPA, the Corps recognizes that additional consultation and other requirements are not yet complete, but the project will be in full compliance prior to construction.*

Consultation is currently ongoing with regards to the determination of effects and potential mitigation of effects listed below, and therefore should be considered preliminary. The effects associated with each Alt have been preliminarily considered for this feasibility study. A final determination of effects, as required under Section 106 (36 CFR Part 800) of the NHPA, will not be made until the project is authorized and the subsequent PED phase begins.

Engineering Regulation (ER) 1105-2-100 Appendix C paragraph C- 4(d)(6)(a) states that results of cultural resources investigations conducted during the feasibility phase and if needed, the PED phase will "serve as the basis for formulation of plans for management of historic properties prior to or during the construction and operational stages of projects". At which time, as required under ER 1105-2-100 Appendix C, paragraph C-4(d)(6)(b) the USACE will determine effects to historic properties and any need "to mitigate adverse project effects on National Register and eligible properties" and to "serve as the basis for negotiation of a Memorandum of Agreement (MA) (if no MA has been previously prepared) with the SHPO/THPO and, if appropriate, the advisory council on Historic Preservation (ACHP) specifying actions which will be taken by the Corps of Engineers prior to or during the project construction period to mitigate adverse effects on National Register and eligible properties."

For each component discussion below, the environmental effect is determined when compared to the future without conditions (FWO). For this document, the use of the term cultural resources includes significant historic properties that are determined eligible or potentially eligible for NRHP listing, and culturally significant sites. See **Section 10** in the Main Document for definitions of terms.

C.2.2.17.1 Draft Preliminary Operations Manual (DPOM)

This component of CEPP involves the development of a draft preliminary operation plan for each component or feature of the project. More information about the draft preliminary operation plan is recorded in **Section 6.6.5**. It should be noted that currently there are approximately 350 significant or

NRHP eligible cultural resource sites, including five districts and one World Heritage site (ENP) recorded within the APE for CEPP. There are also numerous culturally significant properties to both the Seminole Tribe of Florida and the Miccosukee Tribe of Florida within WCA 3 and Everglades National Park.

Two significant traditional cultural properties (TCP), Airboat Association of Florida (8DA6768A) and Coopertown (8DA6767A), associated with the modern Gladesmen culture group, and one Miccosukee Tribe of Indians of Florida residential camp (Osceola Camp) are located south of the L-29 levee. These properties are considered culturally significant. Also, three structures (8DA6768, 8DA11526, and 8DA115267) are located on and associated with 8DA6768A and are considered significant historic properties.

Effects: For this component of CEPP, there are many uncertainties, some of which are identical to those described in the ERTP EIS. Ongoing ERTP investigations center around uncertainties surrounding the effects fluctuating water would have on subsurface cultural material. Another uncertainty is the velocity that water will be flowing from the L-4 Spreader feature and from within the Blue Shanty flow way. Water velocity can cause erosional effects, which would be considered an adverse major long-term effect to historic properties. Once a determination of effects of fluctuating water on cultural resources has been identified for ERTP (ca. 2016) and the CEPP enters into the PED phase, Section 106 consultation for the CEPP DPOM should continue. Alternatives 4R and 4R2 could potentially affect the TCP 8DA6768A and associated historic properties 8DA6768, 8DA11526, and 8DA115267. Based on the Department of Interiors ongoing mitigation of Coopertown (8BD6767A) as part of Tamiami Trails Next Steps, there will be no effect.

During the PED phase and refinement of the DPOM, consultation with all interested parties will resume and an effects determination will be made prior to operation. Mitigation of Effects: Mitigation for the TCP Airboat Association of Florida (8DA6768A) could potentially involve purchasing any necessary easements, which would reduce any adverse effect. Effect to 8BD6768A associated historic structures, could be reduced by potentially raising the structures. For the remainder of the effects caused by the DPOM, mitigation is unknown at this time.

North of Redline

C.2.2.17.2 Lake Okeechobee

There are no changes from the FWO for this component of Alts 4R and 4R2. Effects: There would be no effect to cultural resources.

C.2.2.17.3 Northern Estuaries

This component of Alts 4R and 4R2 proposes to redirect a percentage of water currently flowing from Lake Okeechobee into the eastern and western northern estuaries, south into the Miami Canal and the North New River Canal. Effects: This decrease of freshwater into the estuaries would have no effect to cultural resources.

C.2.2.17.4 EAA A-2 FEB

The EAA A-2 FEB consists of a perimeter levee to confine the water, potential grading within the interior of the FEB footprint, improvements to existing agriculture canals, and improvements to existing and/or constructing new structures or features. A cultural resource Phase I Survey of this project component was conducted specifically for CEPP in 2013 to identify and assess cultural resources within the FEB footprint. As a result, four historic sites were identified, two of which are considered significant (8PB16039, 8PB16040) under NEPA. Effects: Effects to cultural resources sites 8PB16039 and 8PB16040

for Alts 4R and 4R2 are considered major long-term and adverse. Mitigation of Effects: Due to the lack of knowledge of prehistoric occupation sites within the area, Phase III Investigations are recommended for historic property 8PB16039, which would reduce effect. Site 8PB16040 contains human remains and is therefore a culturally significant resource. Mitigation of effects are unknown at this time and will be determined through consultation once the project is implemented.

A new structure (S-623) associated with the operation of A-2 FEB would potentially be constructed along the NRHP eligible Miami Canal (8PB13369). Effects: There would be no effect to cultural resources for Alts 1 through 4. The proposed new structure would not alter either directly or indirectly the characteristics which make the Miami Canal (8PB13369) significant.

Existing structures G-373, G-372 and G-372HL are associated with the operations of STA 3/4 and date to the 1990's, and are therefore not significant. Effects: There would be no effect to significant cultural resources for Alts 4R and 4R2.

South of the Redline

C.2.2.17.5 L-4 Levee and Canal

This component involves degrading the western 2.9 miles of the southern L-4 levee, resulting in the creation of a water spreader feature at the northwestern most boundary of WCA 3A. A pump station near the western terminus of the L-4 degrade would also be constructed. Exact placement of the pump station has not been determined. Although built in ca. 1957, the L-4 Levee and Borrow Canal (8BD5098) is considered a tertiary canal and not a part of the original reclaimation/drainage activities of the early 20th century, which is considered by SHPO and USACE to be the period of significance for eligibility determination. Therefore, 8BD5098 is not considered eligible for the NRHP, nor significant under NEPA. Effects: There would be no effect to significant cultural resources for Alts 4R or 4R2 in the degrading of the southern L-4 levee, nor for the placement of the proposed L-4 Pump Station, regardless of location along the levee/canal.

C.2.2.17.6 S-8 Complex

This component of Alt 4R and 4R2 involves modifications to the S-8 Pump Station (8BD5092) and potentially other structures (G-357, G-404, and L-5-1 bridge)in the vicinity of the pump station to permit flows to the west. Further work is needed to determine if the S-8 Pump Station (8BD5092) is eligible for NRHP listing and therefore is significant under NEPA. The G-357 Gated Culvert, G-404 Pump Station, and L-5-1 bridge have all been either constructed or replaced in the last 20 years and are not considered significant. Effects: A determination of eligibility is need for the S-8 Pump Station (8BD5092), prior to making a determination of effects. Mitigation of Effects: If the S-8 Pump Station is determined significant and adverse effects to any component of the S-8 Pump Station complex are unavoidable, a qualified architectural historian should conduct a Historic American Engineering Record (HAER) and/or Historic American Buildings Survey (HABS). This documentation packet will then be entered into the Library of Congress as well as Florida Master Site Files. These measures would reduce effects to this potentially historic property if needed.

C.2.2.17.7 L-5 Levee and Canal

This component involves improvements to accommodate L-6 and STA 3/4 conveyances, by deepening the L-5 borrow canal and the placement of a gravity pump. The L-5 southern levee and associated borrow canal (known as site number 8BD5099) are depicted on historic aerial photographs (Armando Ramirez, personal communication), however during the 2011 cultural resources survey (FMSF Suvey #.

20487) of the L-5 levee and canal the levee and associated canal were determined not eligible for NRHP listing.

The L-5-1 bridge that joins the L-5 north levee to the L-5 south levee was replaced in the last 20 years and is not eligible for NRHP, nor is the bridge considered significant under NEPA. Effects: There will be no effects to historic properties for this component of Alts 4R and 4R2.

C.2.2.17.8 L-6 Levee and Canal

This component involves deepening and/or widening the L-6 borrow canal, replacement or redesign of the G-336G culverts and removal of the L-6 canal plug. The G-336G and the L-6 canal plug were originally constructed in association with WCA2 operations and are not historic. The L-6 borrow canal appears on historic aerial photographs (Armando Ramirez, personal communication 2013) and therefore would require additional work to determine significance or NRHP eligibility. Effects: Effects to historic properties for this component of the Alts are unknown. Cultural resource investigations would be needed to assess significance of the L-6 levee and associated borrow canal. Mitigation of Effect: If determined a significant historic property, it is recommended that a Level I Historic American Engineering Record (HAER) document is written and submitted to the Library of Congress and the Florida State Archives. This action would reduce the effect..

C.2.2.17.9 Miami Canal (8BD4840/8BD5097)

To improve sheet flow throughout WCA 3A, a portion of the Miami Canal (8BD4840) would be backfilled using spoil material originally excavated during the construction and maintenance of the canal and dredged material from the L-5 modifications. The Miami Canal and associated features/structures have been investigated during seven separate surveys (FMSF Survey # 5844, 14404, 17583, 19090, 19276, 20328, and 20487). As a result, it has been determined that the Broward County reach of the Miami Canal (8BD4840) is eligible for the National Register of Historic Places (NRHP) and is therefore considered significant under NEPA. Effects: Major long term adverse effects to the the historic Miami Canal within Water Concervation Area 3 (8BD4840 and 8BD5097) for Alts 4R and 4R2. Through consultation with the Tribes (**Appendix C.5**), it has been determined that the spoil mounds associated with the Miami Canal do not contain culturally significant sites (i.e., culturally significant flora and/or other culturally sensitive uses), therefore a determination of no effect to culturally significant sites is listed for the use of the spoil material. Mitigation of Effects: It is recommended that a Level I or II Historic American Engineering Record (HAER) document is written and submitted to the Library of Congress and the Florida State Archives. This would reduce the effects of the proposed action.

Greenline/Blueline

C.2.2.17.10 L-67A Levee and Canal

This component involves the placement of gated structure(s) within the L-67A levee and the removal of spoil material deposited during the original construction or maintenance of the L-67A borrow canal and will span approximately 0.5-miles on each side of the structure(s).

Three cultural resource surveys are listed with the State for WCA 3A, one conducted via aerial photographs (FMSF Survey # 602), a Phase I Survey conducted in 2011 (FMSF # 20487) and a Phase I Sample Survey and Phase II Excavation conducted in 2012 specifically for CEPP (FMSF Survey # 20328). During the 2011 survey, the L-67A levee and associated canal (8BD5100) was assessed and determined to be not significant. Results of the 2012 cultural resources survey conducted specifically for CEPP included testing portions of tree islands impacted by the original levee/borrow canal construction. In some cases this involved portions of tree islands with recorded sites that were identified during Survey #

602 using aerial photography. These sites have not been field verified. Only areas of potential effect for sites recorded during Survey # 602 were investigated for CEPP. It also should be noted that existing As-Built Plans for the L-67A and C show that the area immediately underneath the existing levee, and areas between the levee and borrow canal were degraded prior to construction. During the CEPP specific 2012 Survey (FMSF Survey # 20328), no significant cultural resources were identified.

Two culturally significant sites actively used by the Miccosukee Tribe of Indians of Florida are located on two of the spoil mounds west of the borrow canal. Effects: Potential effects to the culturally significant sites for Alts 4R and 4R2 are considered major to moderate long-term adverse effects. There will be no known effects to historic properties. Mitigation of Effects: Effects to the culturally significant sites could be reduced by avoiding the spoil mounds associated with the sites during the PED and construction phase of CEPP. Also, to avoid potential inadvertent discoveries, it is recommended that should spoil mounds be removed within the historic footprint of tree islands, that degrading be terminated at tree island grade, not marsh grade. Previous research conducted by the Corps' archaeologist has shown that compacted spoil material can extend well below tree island grade. Additionally, a professional archaeologist should monitor construction activity within historic tree island footprints to ensure that any discovery is recorded and assessed for significance.

C.2.2.17.11 L-67C Levee and Canal

This project component involves degrading approximately 8-miles of the L-67C levee to promote sheet-flow into the Blue Shanty flowway, constructing one gated structure north of the newly constructed 8.5-mile levee, and removing 6,000-ft of the L-67C levee in association with the new structure.

Two cultural resource surveys are listed with the State for WCA 3A, one conducted via aerial photographs (FMSF Survey # 602), and a Phase I Sample Survey and Phase II Excavation conducted in 2012 specifically for CEPP (FMSF Survey 20328). For tree islands impacted by the original levee/borrow canal construction, only areas of potential effect were investigated. In some cases this involved portions of tree islands with recorded sites that were identified during Survey # 602 using aerial photography. These sites have not been field verified. Only areas of potential effect for sites recorded during Survey # 602 were investigated for CEPP. It also should be noted that existing As-Built Plans for the L-67 A and C show that the area immediately underneath the existing levee, and areas between the levee and borrow canal were degraded prior to construction. During the CEPP specific 2012 Survey, no significant cultural resources were identified within the APE for this feature. Also the L-67C was built in 1968 and thereforedoes not meet the age criteria of 50-years required for accessing eligiblility. Based on information gathered during the accessment of L-67A, once the age criteria is met, it is probable that the L-67C is not historically significant. Effects: For this component of Alt 4Rs and 4R2, there would be no effect to cultural resources. Mitigation of Effects: To avoid potential inadvertent discoveries, it is recommended that should spoil mounds be removed within the historic footprint of tree islands, that degrading be terminated at tree island grade, not marsh grade. Previous research conducted by Corps archaeologist has shown that compacted spoil material can extend well below tree island grade. Additionally, a professional archaeologist should monitor construction activity to ensure that any discovery is recorded and assessed for significance.

C.2.2.17.12 L-29 Levee

This component involves degrading of approximately 4.3-miles of the L-29 Levee in the Blue Shanty flow way and the placement of a divide structure at the terminus of the western Tamiami Trail bridge. The original construction of the L-29 impacted two large tree islands. Through consultation with the Cultural Resource Representative to the Miccosukee Tribe of Indians of Florida, these islands have been

identified as being culturally significant. Multiple surveys have been conducted to identify cultural resources within WCA 3A and 3B, one conducted via aerial photographs (FMSF Survey # 602), Survey # 17032, Survey # 283, a Phase I Survey conducted in 2011 (FMSF Survey # 20487), and a Phase I and Phase II Survey conducted in 2012 specifically for CEPP (FMSF Survey # 20328). With information gathered from these surveys and others in similar environments, it is highly probably that historic sites will also be located on these islands.

The ValuJet Flight 592 Crash Memorial is also located along the L-29 levee. Although the Memorial is not historic, it is frequently visited by those directly or indirectly affected by the accident. Therefore, the Memorial is considered culturally significant and should be preserved in place. If preservation is not viable, consultation with all family members of the victims, and local residents should occur prior to completion of the design-build phase.

There is also one Miccosukee Tribe of Indians of Florida residential camp (Tigertail Camp) located atop the L-29 levee. The Tigertale Camp is considered culturally significant.

Effects: Alternative 4R and 4R2 could potentially have major long-term adverse effects to two sites deemed culturally significant to members of the Miccosukee Tribe of Indians of Florida. These sites were originally impacted by the levee and borrow canal construction in the mid-late 1960's. Based on previous research, it is highly probable that these two tree islands contain historic resources of unknown significance. Cultural resource investigations on these islands would require further consultation with the Miccosukee Tribe of Indians of Florida (Oceola Camp) prior to fieldwork. Based on preliminary design plans for Alts 4R and 4R2, there would be no effect to the Valujet Flight 592 Crash Memorial, or the Tiger Tail Camp. Mitigation of Effects: Avoid placing structures within known culturally significant sites, significant historic properties, currently occupied camps could reduce the effect. Potential adverse effects to potential historic properties impacted by the original levee construction could be reduced by avoiding tree islands and/or by limiting the depth of levee removal to not exceed tree island grade. Additionally, a professional archaeologist should monitor construction activity within historic tree island footprints to ensure that any discovery is recorded

C.2.2.17.13 S-333 Modifications

This component of Alt 4R and 4R2 involves constructing an additional structure to increase the S-333 capacity. The new structure would be located just north of the S-333. Exact placement of the structure is preliminary.

There are no known high probability areas for archaeological sites located within the area of potential effect. The ValuJet Flight 592 Crash Memorial is also located along the L-29 levee just east of the S-333 structure. Although the Memorial is not historic, it is frequently visited by those directly or indirectly affected by the accident. Therefore, the Memorial is considered culturally significant and should be preserved in place. If preservation is not viable, consultation with all family members of the victims, and local residents should occur prior to completion of the design and build phase. Effects: Based on preliminary design plans for Alts 4R and 4R2, there would be no effect to the Valujet Flight 592 Crash Memorial.

C.2.2.17.14 L-67D Levee and Flow way within WCA 3B (Blue Shanty)

This component involves constructing a levee within WCA 3B to connect the L-67A levee with the L-29 levee, thereby creating a flow-way for water to pass from WCA 3A into Shark River Slough. Working closely with project engineers, areas of concern have been identified in an effort to avoid significant

cultural resources or areas of high probability (i.e. tree islands and areas currently in use by the Miccosukee Tribe of Indians of Florida) within the footprint of the proposed levee. Based on the multiple surveys conducted within the similar environmental areas (FMSF Survey # 602, 286, 1616, 17032, 18093, 1615, 904, 1009, 1014, 1187, 1307, 6968, 7667, 20487, and the CEPP specific 2012 Survey (FMSF Survey # 20328) and in conjunction with consultation with the Tribes, there is a high probability for significant cultural resources to be located within the flow way. Also, modeling results indicate that water depth could exceed current stages to the point that it could prove detrimental to lower elevated tree islands within the flow way that have not undergone a Phase I Survey. The exact footprint of this feature is unknown at this time. Effects: Effects to cultural resources for Alts 4R and 4R2 are unknown. Once the footprint of the L-67D levee and the APE for the flow way is determined, and early during the PED phase, an integrated Phase I and Phase II Survey would be conducted to identify and assess significant cultural resources that may be located on high probability areas (tree islands) within the proposed flow way. Mitigation of Effects: Any adverse effect could be reduced by avoid impacting tree islands.

C.2.2.17.15 Old Tamiami Trail (8DA6453/8DA6510)

This component involves the removal of approximately 6-miles of the original Tamiami Trail from the L-67 Extension west to Shark Valley Loop Road. The original Tamiami Trail is located within Everglades National Park (ENP). The Tamiami Trail and associated features/structures have been reported and evaluated during four separate surveys (FMSF Survey #6687, 12129, 17445, and 18181). As a result, it has been determined that the original Tamiami Trail and specific features/structures associated with the roadway are significant and therefore are eligible for the National Register of Historic Places (NRHP).

Effects: There would be major long-term adverse effects to the Tamiami Trial (8DA6453) and associated features. Mitigation of Effects: Portions of 8DA6453 has previously been impacted by the construction of the 1-mile Tamiami Trail Bridge. Impacts to the site are currently being mitigated with an Memorandum of Agreement (MOA) to be signed by ENP, USACE, and SHPO. Through consultation with ENP, it is probable that the current projects impacts to the original Tamiami Trail could be included in the current mitigation plan. This would reduce the effect. Further consultation is needed.

C.2.2.17.16 L-67 Extension Levee Removal

This component involves the backfilling of the L-67 Extension borrow canal using associated levee material. This component is located within ENP, a recorded World Heritage site. In January 2013, USACE and ENP employees conducted a Phase I Survey (FMSF # pending) of potential high probability areas impacted by the original construction of the L-67 Extension levee and associated borrow canal. The L-67 Ext. levee and associated borrow canal (ca. 1967), as well as associated features (S-347 (1987)and S-346 (1987)) do not meet the age criteria of 50-years required for accessing NRHP eligibility, nor are these features eligible under Criteria G. Based on information gathered during the research of other canals, levees, and features within the CEPP APE, it is highly probable that the L-67 Ext. and associated features are not eligible for NRHP listing and therefore will not be considered historically significant. See SHPO to Corps letter dated 10-15-2013 in Appendix C.5 (FMSF site # pending). No significant cultural resource sites were located. Effects: There would be no effect to cultural resources for Alts 4R and 4R2. However, to avoid potential inadvertent discoveries, it is recommended that should levee material be removed within the historic footprint of tree islands, that degrading be terminated at tree island grade, not marsh grade. Previous research has shown that compacted spoil material can extend well below tree island grade. Additionally, a professional archaeologist should monitor construction activity within historic tree island footprints to ensure that any discovery is recorded.

Yellowline

C.2.2.17.17 L-31N Seepage Barrier / L-31N Pump Station(s)

This component involves the construction of a seepage barrier within the existing L-31N levee and/or the construction of pumps. Three surveys have been conducted along the L-31N Levee (FMSF Survey # 11698, 16709, 18093), which resulted in the identification of one site recommended as potentially eligible for the National Register. The U.S. Army Corps concurs with this recommendation and considers 8BD2104 as eligible for NRHP listing. Effects: There could potentially be major long-term adverse effects to the Levee Cut Site (8BD2104) dependent upon pump location. Mitigation of Effects: Consideration should be given to the placements of these pump stations or structures. If placement avoids direct or indirect impact to site 8DA2104, then a no effect determination would be made. The effect determination for 8DA2104 should be revisited once feature specific plans and specification for the project are developed.

C.2.2.17.18 S-356

This component involves changes to the S-356 Pump Station. Based on examination of historic aerial photographs, the original construction of the pump station did not impact any tree islands within the construction footprint. As previously stated, based on previous research, tree islands are considered high probability for cultural resource locations. Effects: The S-356 Pump Station is not a historic structure, nor did original construction impact areas of high probability areas. Regardless of how the S-356 is changed, there would be no effect to cultural resources for this component of Alt 4R and 4R2.

C.2.2.17.19 G-211 Operational Refinements

This component involves the utilization of current coastal infrastructure (canals and associated features) to convey seepage south. Effects: There would be no effect to cultural resources.

C.2.2.18 Invasive and Native Nuisance Species

Alternatives 4R and 4R2 have the potential and likelihood for establishment and spread of non-native invasive and native nuisance species. Proposed restoration activities may affect ecosystem drivers that directly or indirectly influence the invasiveness of non-native species. These factors may affect invasive species positively or negatively, depending on the unique characteristics of individual species and the environmental conditions for a given biological invasion (Doren et al. 2009). For example, shortened surface water drawdowns may reduce the recolonization rates of melaleuca in sawgrass marsh while increasing habitat suitability for Old World climbing fern on tree islands. Many of the areas where features are proposed are currently inhabited by non-native invasive and native nuisance species. Construction of the proposed features has the potential to spread the existing non-native invasive and native nuisance species on site as well as introduce new invasive species via contaminated equipment. Disturbed areas resulting from construction are likely to become established with non-native invasive and native nuisance species. New flows created by operations of the proposed features may serve as vectors to spread invasive and native nuisance species into new areas. The large number of existing and potential invasive plant and animal species and the often incomplete knowledge of invasive mechanisms for each species create moderate to high uncertainty in this evaluation. Long-term monitoring in an adaptive management framework is critical to ensure efficient management of the most threatening non-native invasive species in the restoration footprint.

C.2.2.18.1 Lake Okeechobee and the Northern Estuaries

Alternatives 4R and 4R2 would reduce freshwater flows from Lake Okeechobee to the Caloosahatchee and St. Lucie estuaries, allowing for slightly higher salinity levels in the estuaries. The reduced freshwater outflows are not expected to have an impact on non-native invasive or native nuisance

species. Existing invasive species under active management are expected to persist at baseline levels if current funding levels are sustained (e.g., melaleuca). Existing species not under active management or which are ineffectively controlled are expected to increase in abundance and spatial extent (tropical American water grass). New invasions of non-native plant and animal species are expected but estimates of species number and severity of impacts are conjectural.

C.2.2.18.2 A-2 Flow Equalization Basin

There are invasive and native nuisance species to consider with the proposed FEB A-2. Species of concern include Brazilian pepper, torpedo grass, tropical American watergrass, water hyacinth, water lettuce, and hydrilla. The proposed A-2 FEB lands currently are agricultural lands. Brazilian pepper exists along the agricultural canals. Once the proposed A-2 FEB is operational, the water levels are likely to inhibit growth and recruitment of Brazilian pepper. All upland sites (e.g., levees) are expected to experience colonization of Brazilian pepper, torpedo grass, paragrass, and other invasive species common in ruderal sites. The proposed four-mile spreader canal would require continual maintenance of floating, emergent and potentially submersed plant species in order to maintain the function of the canal. It is expected that increased sedimentation immediately downstream of the spreader would result in succession to large stands of Carolina willow and cattail and this area may require maintenance to achieve target flow rates. In addition, the seepage canal would require continual maintenance to control both non-native invasive and native nuisance species. Due to eutrophic conditions and variable hydroperiods, many invasive species would aggressively invade and are likely to be costly and difficult to control. Therefore, control efforts focused at maintaining the primary functions of the proposed A-2 FEB (e.g., conveyance capacity) are preferred over aggressive eradication efforts typically applied to natural areas. Invasive/nuisance species in this category include, but are not limited to torpedo grass, hydrilla, water hyacinth, and water lettuce. In all alternatives, these species have the potential to interfere with surface water conveyance immediately upstream of water control structures. There are many species that could establish both in FEBs and WCAs. Establishment of these species in the proposed A-2 FEB could be part of an invasion pathway to natural areas downstream (i.e. WCA 3A/3B, ENP). For this reason, diligent monitoring and rapid response control measures for these species would need to be carried out during construction and operations phases. Examples of such species include tropical American watergrass, Wright's nutrush, West Indian marshgrass, Nile monitor, and bullseye snakehead.

There are two recreational access points proposed to the proposed A-2 FEB. Access points provide opportunity for the introduction of invasive species. Boats and trailers can serve as a vector for new species introductions.

C.2.2.18.3 Diversion of L-6 Flows and L-5 Improvements

Deepening of the L-5 has the potential to reduce productivity of various species of SAV (including hydrilla), but would not eliminate suitable habitat for their establishment and growth (Langeland 1996). Alternatives 4R and 4R2 may improve habitat for non-native tropical fish species which utilize deep water zones to avoid cold temperature events (Trexler et al. 2000).

C.2.2.18.4 L-4 / L-5 – Spreader Canal and Levee Degradation

Northwest WCA 3A has dried out significantly since the area was compartmentalized. The vegetation has shifted from ridge and slough to woody shrubs and small trees including Carolina willow, wax myrtle, Brazilian pepper, and melaleuca. The flows provided by the spreader canal into northwest WCA 3A are expected to increase wet season stages and decrease duration of surface water draw downs in the northern portions of WCA 3A. This may reduce recruitment rates of some invasive or nuisance

species, such as Carolina willow and Brazilian pepper, and may facilitate expansion of other invasive or nuisance species, such as cattail and paragrass. The proposed spreader canal would require continual maintenance of floating, emergent, and, potentially, submersed plant species in order to maintain the function of the canal. It is expected that increased sedimentation immediately downstream of the spreader would result in succession to stands of Carolina willow and cattail and this area may require maintenance to achieve target flow rates. Similar areas in ENP are also invaded by Brazilian pepper and Old World climbing fern. The remaining portions of the levee would offer suitable habitat for Burmese pythons. Invasive species could be introduced into northern WCA 3A with the new flows from the spreader canal. The degraded levee area may be invaded by non-native invasive and native nuisance obligate wetland plant species.

Model output for WCA 3A suggests substantial decreases in dry out periods in the northern reaches of WCA 3A. This is likely to reduce the rate of spread for certain species, especially Brazilian pepper, Australian pine, torpedo grass, and Napier grass. Melaleuca recruitment would also continue but at a reduced rate. Other species more suited to longer periods of inundation may find conditions more favorable for establishment and spread. These include but are not limited to Old World climbing fern, Island apple snail, West Indian marsh grass, paragrass, and potentially Peruvian primrose willow. Diligent monitoring and control efforts would be recommended to minimize establishment of new plant species in these areas.

Continued maintenance of the remaining portions of the L-4 levee is assumed. If regular mowing is not carried out, this segment of levee would become invaded by a number of invasive plants and animals, such as Brazilian pepper, Napier grass, bishopwood, cogongrass, Burmese pythons, feral hogs, and Nile monitors.

C.2.2.18.5 Miami Canal Backfill – S-8 to I-75

Backfilled portions of the Miami Canal may be invaded by non-native invasive and native nuisance wetland plant species. Invasion by paragrass, torpedograss, and cattail is expected if backfill operations result in elevated nutrient availability. Spoil mounds along the Miami Canal in WCA 3A currently supports high densities of Brazilian pepper and other invasive plants. Degradation of these spoil deposits would result in the removal of approximately 200 acres of Brazilian pepper. This would reduce an important seed source and lower bird dispersal to nearby tree islands. While there is uncertainty about the impacts of non-native fish species on native fauna (Trexler et al. 2000), backfilling the canal would reduce available deep water habitat for non-native fish species and could reduce further expansion.

Preserved planted tree islands and the proposed spoil island creation efforts would experience immediate and long-term susceptibility for biological invasion. Elevated nutrient regimes on the new islands would promote invasion of numerous invasive species, including Brazilian pepper, napier grass, climbing cassia, Peruvian primrose willow, and torpedograss. These elevated areas are also expected to provide excellent habitat for Burmese pythons and Nile monitors.

C.2.2.18.6 L-28 Levee Degradation / Backfill

Continued maintenance of the remaining portions of the L-28 levee is assumed. If regular O&M vegetation management is not carried out, fallow segments of levees are likely to be invaded by a number of invasive plants and animals, such as Brazilian pepper, Napier grass, bishopwood, cogongrass, Burmese pythons, feral hogs, and Nile monitors. Backfilled portions and the degraded levee area may be invaded by non-native invasive and native nuisance wetland plant species.

C.2.2.18.7 Increase Capacity of S-333

The additional flows from increasing the capacity of S-333 are expected to have a minimal effect on invasive species populations. Existing invasive species under active management are expected to persist at baseline levels if current funding levels are sustained (e.g., water hyacinth). Existing species not under active management, or which are ineffectively controlled, are expected to increase in abundance and spatial extent (e.g., roundleaf toothcup). New invasions of non-native plant and animal species are expected but estimates of species numbers and severity of impacts are conjectural.

C.2.2.18.8 L-67A Gated Structures / Spoil Removal

The proposed gated structures on the L-67A have the potential to spread cattail, torpedograss, and non-native fish species downstream of the structure and into the gap between L-67A and L-67C. Cattail and torpedo grass are also expected to colonize spoil removal areas. It is expected that non-native fish species would establish at the outflow, where water levels are deeper. Existing non-native fish species could move from the canal into the gap, but they are not expected to maintain substantial populations in the marsh due to seasonal drawdowns. Many non-native fish are documented to move from canals to the marsh during the wet season, but do not venture too far from the canal and return to the canal as water levels recede (Trexler 2000). There is a potential for invasion by new aquatic species capable of tolerating seasonal drawdowns but the number of species and severity is conjectural.

C.2.2.18.9 L-67C Levee Degradation

The proposed gaps would provide a pathway for aquatic species currently present in the L-67C canal to spread into WCA 3B. Existing invasive species under active management in WCA 3B are expected to persist at baseline levels if current funding levels are sustained (e.g., melaleuca). Existing species not under active management or which are ineffectively controlled are expected to increase in abundance and spatial extent (Old World climbing fern). New invasions of non-native plant and animal species are expected but estimates of species numbers and severity of impacts are conjectural. The proposed 6,000-foot gaps in the L-67C levee would provide an open pathway for cattail spread into WCA 3B. The extent of spread is uncertain.

C.2.2.18.10 Outflow structures out of WCA 3B

Agricultural canals in WCA 3B currently release water into the L-29. There is potential for new non-native invasive species to be transferred from WCA 3A or L-67A through the new culverts and levee degrade area into WCA 3B, L-29, and eventually into ENP.

C.2.2.18.11 Build North-South Levee in WCA 3B

The construction of a north-south levee in WCA 3B would cause significant disturbance within the construction footprint and adjacent marsh. Regular maintenance would be required to ensure non-native invasive plant species do not establish along the levee. Cattail is likely to establish along the entire eastern side of the levee. Existing invasive species in the affected area that are under active management should persist at baseline levels if current funding levels are sustained (e.g., melaleuca). Existing species not under active management or which are ineffectively controlled are expected to increase in abundance and spatial extent. New invasions of non-native plant and animal species are expected but number of species and severity of impacts are undetermined.

C.2.2.18.12 L-67 Extension – Levee Degradation / Backfill

The L-67 Extension canal and levee system extends south into ENP. This area is now invaded by numerous non-native invasive plants and also serves as habitat for Burmese pythons and feral hogs.

Removal of the L-67 Extension levee would remove suitable habitat for Brazilian pepper, napier grass, climbing cassia, torpedo grass, guava, and Australian pine. Removal of the L-67 Extension levee would also reduce habitat for the Burmese python, feral hogs, and potentially, the Argentine black and white tegu. Island apple snails may find the degradation footprint as suitable habitat if final grade is lower than the surrounding marsh.

C.2.2.18.13 L-29 Levee Degradation

Degradation of the L-29 levee would open surface water connectivity between the L-29 canal and WCA 3B (Blue Shanty flowway). This is likely to promote the expansion of several invasive species currently limited to the L-29 canal, particularly roundleaf toothcup, island apple snail, and numerous non-native fish species. There is uncertainty whether these species would be able to persist far from the canal since many are unable to tolerate conditions during dry season drawdowns.

C.2.2.18.14 Divide Structure on L-29

This feature is expected to have minimal effect on invasive species. Maintenance of submersed and floating vegetation would be required to ensure operational functionality of the structure.

C.2.2.18.15 Increase S-356 Capacity to 1,000 cfs

The additional flows from increasing the capacity of the S-356 structure may slightly reduce recruitment rates of melaleuca and other invasive plants in northern portions of ENP.

C.2.2.18.16 Remove ~6 Miles of the Old Tamiami Trail roadway from L-67Extension to Tram Road

This area is now heavily invaded by numerous invasive plants and also serves as habitat for Burmese pythons and feral hogs. Alternatives 4R and 4R2 would remove suitable habitat for Brazilian pepper, napier grass, climbing cassia, torpedo grass, guava, and Australian pine. Removal of the old roadway would also reduce habitat for the Burmese python, feral hogs, and potentially, the Argentine black and white tegu. Island apple snails would continue to thrive in the adjacent canal and may spread further south as a result of removing the old road.

C.2.2.18.17 G-211 Operational Modifications / Coastal Canals Conveyance

This feature is expected to have minimal effects on non-native invasive and native nuisance species. Existing invasive species under active management are expected to persist at baseline levels if current funding levels are sustained (e.g., hygrophila). Existing species not under active management or which are ineffectively controlled are expected to increase in abundance and spatial extent (roundleaf toothcup). New invasions of non-native plant and animal species are expected but number of species and severity of impacts are undetermined.

C.2.2.18.18 Penetrating Seepage Barrier

The depth and duration of surface water drawdowns in northeastern ENP are expected to decrease with Alternatives 4R and 4R2. These changes in hydroperiods are expected to reduce recruitment rates of Australian pine, Brazilian pepper, and to a lesser extent, melaleuca. These changes may improve conditions for other invasive plant species such as tropical American water grass, West Indian marsh grass, and roundleaf toothcup.

C.2.2.19 Cumulative Effects

Cumulative effects are defined in 40 CFR 1508.7 as those effects that result from:

the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Cumulative effects for the proposed action were assessed in accordance with guidance provided by the President's Council on Environmental Quality (CEQ). The primary goal of cumulative effects analysis is to determine the magnitude and significance of the environmental consequences of the proposed action in the context of the cumulative effects of other past, present, and future actions. The following summarizes past, present, and projected USACE efforts that cumulatively affect the regional environment of south Florida (**Table C.2.2-16**). In addition, there are efforts underway by other Federal, State, and local agencies, as well as non-governmental organizations, that are too numerous to mention, that are all working towards similar restoration goals. **Table C.2.2-17** shows the net cumulative effects of the various resources which are directly or indirectly impacted. CEPP is expected to contribute to a net beneficial cumulative impact on the regional ecosystem.

C.2.2.20 Past, Present, and Reasonably Foreseeable Actions Affecting Resources within the Project Area

Prior to drainage and compartmentalization, the Everglades were a shallow wetland conveying water from Lake Okeechobee to the southern coast of Florida. The Everglades Drainage District, encompassing 7,150 square miles, was created in 1907 by Florida Governor Napoleon Bonaparte Broward for the purpose of drainage and reclamation of the Everglades (Light and Dineen 1994). In the early 1900s, the Everglades Drainage District constructed several canals that impacted Lake Okeechobee and the Greater Everglades. By 1917, the West Palm Beach, Hillsboro, North New River and Miami Canals had been constructed (Allison et al., 1948). By 1931, the outlet from Lake Okeechobee to the Caloosahatchee River was improved, and the completion of the St. Lucie Canal east to the Atlantic Ocean provided another way of controlling lake levels. The Bolles and Cross canals became connectors to the four major canals south of Lake Okeechobee bringing the total miles of canal excavated to 440 (Light and Dineen 1994). The Everglades Drainage District also constructed 47 miles of levees around the southern rim of Lake Okeechobee during this time (Allison et al., 1948). Within a similar time frame (1915-1928) the construction of Tamiami Trail was completed which linked Miami with Naples on the west coast. Hurricanes in 1926 and 1928 shifted attention from Everglades drainage to controlling flooding around Lake Okeechobee. In 1930, the USACE became a major participant with the state (i.e., Okeechobee Flood Control District) in controlling flooding around Lake Okeechobee. Florida agreed to share a portion of the costs to increase discharges from the lake, improve canal works, and reconstruct and enlarge the levees around it (Light and Dineen 1994). The effect of levees on the agricultural area south of Lake Okeechobee was dramatic and sugarcane production was doubled in 10 years between 1931 and 1941. Drainage of the Everglades and the linkage of the east and west coast, promoted urban growth in south Florida and the population escalated from 22,961 in 1900 to 228,454 by 1930 (Dietrich 1978). During the 1930s and into the 1940s, construction was abandoned and maintenance ceased on Everglades Drainage District works (Light and Dineen 1994).

Although modifications to Lake Okeechobee and the Everglades began in the early 1900s, the greatest influence on the alteration of flow was the Central and Southern (C&SF) Flood Control project, which was originally authorized by Congress in 1948. The C&SF Flood Control project was designed to lower water levels east of the eastern protective levee by 4 to 5 feet (Light and Dineen 1994). Increased flood protection coupled with lowering of the water table east of the levee had a dramatic effect on urbanization and development and acted as a catalyst for a population explosion in south Florida. Between 1952

and 1954 the eastern perimeter levee along the WCAs was constructed from Palm Beach to Dade County in order to stop sheet flow from the Everglades toward the urbanizing eastern coastal areas (Light and Dineen 1994). Between 1954 and 1959 additional levees (L-1, L-2, L-3, L-4, L-5, L-6, and L-7) were constructed to partition the EAA from the remainder of the Everglades and the old Everglades Drainage District Canals (West Palm Beach, Hillsboro, North New River, and Miami) were deepened within the EAA to provide better flood conveyance from the agricultural area into the WCAs (Light and Dineen 1994).

Between 1960 to 1963 substantial portions of the C&SF Flood Control project were completed. Construction of the levees surrounding WCA 3 was completed by 1963 with the L-67A levee dividing WCA 3 into two compartments, WCA 3A and WCA 3B (Light and Dineen 1994). The L-67A levee (completed 1962) and the parallel L-67C levee (completed 1966) were originally constructed for several reasons, including as a step-down system to reduce seepage to the east to allow for urban and agricultural developments in Miami-Dade County, and to increase storage of water in WCA 3A to provide water supply to an expanding urban population to the east. S-151 and S-31 were also constructed during this time period. These two structures improved the discharge capacity of the Miami Canal to coastal communities (Cooper and Roy, 1991), further exacerbating the unnatural drainage of northern WCA 3A. In an attempt to remedy excessive drainage caused by the Miami Canal, two structures, S-339 and S-340, were built across the Miami Canal in 1980 to block water from flowing directly down the canal, except at times of extreme high water or when increased conveyance capacity is needed to deliver water for the ENP and/or the LEC. Upstream from each structure, water was expected to flow laterally from the canal into the marsh through 100-foot gaps that had been left at 500-foot intervals along the Miami Canal sidecast spoil material. In combination with the northern levees of WCA 3A (L-4 and L-5), the Miami Canal has substantially impacted historical sheetflow and natural wetland hydroperiods. As a result, during wet periods, the natural capability of WCA 3A to store water is lost and the Miami Canal effectively over-drains the area. These hydrologic changes have increased the frequency of severe peat fires and have also resulted in the loss of ridge and slough topography that was once characteristic of the area. Northern WCA 3A has become largely dominated by sawgrass, cattail and scattered shrubs and lacks the structural diversity of plant communities seen in central and western WCA 3A.

Completion of the L-29 levee in 1962 led to ponding in the southern portions of WCA 3A. Exacerbating this problem were the major canal systems (i.e. Miami Canal, L-67A) which accelerate the flow of water from north to south within WCA 3A, drying the north while further ponding the south (Zaffke 1983), especially along the L-67A and L-29. As a result of this ponding, extended hydroperiods and increased water depths led to changes in vegetation communities in which wet prairies were displaced by aquatic slough communities (Zaffke 1983, Tanner et al. 1987). In addition, many tree islands within southern WCA 3A were lost due to increased water depths (Craighead 1971), with many of the remaining islands showing signs of stress. Wood and Tanner (1990) documented the trend in southern WCA 3A toward deep water lily dominated sloughs due to impoundment within the southern end of WCA 3A.

Four control structures located along the L-29 were constructed between 1960 and 1963 (S-12A, S-12B, S-12C, and S-12 D). These structures were used to regulate discharge from WCA 3A to the western part of Shark River Slough (Light and Dineen 1994). Construction of the L-67 Extension levee, extending 8 miles south of Tamiami Trail, was completed in 1967 in order to facilitate water delivery from WCA 3A to ENP. Completion of the L-67A and L-67C canal and levee system intercepted water that would otherwise flow to WCA 3B. With its impoundment, WCA 3B became isolated from the rest of the Everglades with inflows and outflows limited to rainfall and levee seepage. Within WCA 3B, the ridge and slough landscape has become severely compromised by the virtual elimination of overland sheetflow and has largely turned into a sawgrass monoculture where relatively few sloughs or tree islands remain.

Loss of sheetflow to WCA 3B has also accelerated soil loss reducing elevations of the remaining tree islands in WCA 3B, making them vulnerable to high water stages. With the construction of WCA 3A, WCA 3B and the L-67 Extension Levee, flows to ENP became subject to water supply deficits during the dry season and excesses during the wet season, resulting in a decline in ecological quality.

Among the first Congressional actions to offset adverse impacts to ENP by improving the supply and distribution of water, the Flood Control Act of 1968 provided for modifications to the C&SF Project through the implementation of the ENP South Dade Conveyance System (SDCS). Additional Congressional actions ensued, including the ENP Protection and Expansion Act of 1989, which expanded ENP to incorporate NESRS and the East Everglades into the Park's boundary for protection and restoration of the natural hydrologic conditions within ENP. This Act also provided authorization for development of the Modified Water Deliveries (MWD) to ENP project. The goal of the MWD Project was to improve water deliveries into ENP and, to the extent practicable, take steps to restore the natural hydrologic conditions within ENP. The Water Resources Development Act (WRDA) of 2000 established CERP to provide for the restoration, protection and preservation of the water resources of central and southern Florida, including the Everglades and Florida Bay (USACE 1999).

CERP contains 68 components that include approximately 217,000 acres of new reservoirs and wetlands-based water treatment areas. A number of operational components have also been identified in CERP and will, in most cases, occur in conjunction with related construction features. The operational features in CERP include: a modified Lake Okeechobee regulation schedule; environmental water supply deliveries to the Caloosahatchee and St. Lucie Estuaries; modifications to the regulation schedules for WCAs 2A, 2B, 3A, 3B, and the current rainfall delivery formula for ENP to implement rain-driven operations; modified Holey Land Wildlife Management Area Operation Plan; Modified Rotenberger Wildlife Management Area Operations Plan; a modification for coastal well field operations in the Lower East Coast (LEC); LEC utility water conservation; and operational modifications to the southern portion of L-31 and C-111.

CERP projects would increase the supply of freshwater for the Everglades and south Florida ecosystem. Large areas within the study area would be used to increase water storage resulting from CERP Projects for the overall gain and long term benefit of the regional system. These project features would provide important storage functions and are essential to the overall restoration of the freshwater marshes and the estuaries of the greater Everglades ecosystem. Project components in the area, especially storage, seepage control, and redirection of point source canal flows to overland flow will act to restore more natural freshwater flows to the northern and southern estuaries, reduce seepage losses from the Everglades, improve recharge of the Biscayne aquifer, and should result in other beneficial environmental effects.

Construction has begun on the first generation of CERP project modifications already authorized by Congress. These include the Indian River Lagoon-South Project, the Picayune Strand Restoration Project, and the Site 1 Impoundment Project. The second generation of CERP projects, authorized in WRRDA 2014, includes the Biscayne Bay Coastal Wetlands Project, Broward County Water Preserve Areas Project, the Caloosahatchee River (C-43) West Basin Storage Reservoir, and the C-111 Spreader Canal Western Project. These projects will result in significant environmental benefits to the CERP project area, improving the quantity, quality, timing and delivery of water to the natural system. Further information on the above mentioned CERP projects assumed to be in the future without project conditions are provided in **Section 2** (**Existing and Future Without Project Conditions**) and **Appendix C.1** (**Existing and Future Without Project Conditions**).

Non-CERP projects assumed to be in the future without project condition for CEPP, which incorporate similar restoration goals of improving flow and water quality to the Everglades, include the DOI Tamiami Trail Modifications Next Steps (TTMNS) Project and the Restoration Strategies Regional Water Quality Preliminary Plan (SFWMD 2012). The DOI through the National Park Service (NPS) and ENP completed a study to evaluate the feasibility of additional Tamiami Trail bridge length, beyond that to be constructed pursuant to the MWD Project, to restore more natural water flow to ENP and Florida Bay and for the purpose of restoring habitat within the ENP. The TTMNS project was authorized by Congress in the Consolidated Appropriations Act, 2012. The Restoration Strategies Regional Water Quality Preliminary Plan describes resulting projects developed to address water quality concerns associated with existing flows to the Everglades Protection Area (EPA) to achieve water quality standards established for the Everglades. The SFWMD is implementing a technical plan to complete six projects that will create more than 6,500 acres of new STAs and 110,000 acre feet of additional water storage through construction of FEBs.

The C&SF Flood Control project has numerous water management structures consisting of culverts, spillways, and pump stations that have specified operating criteria for managing or regulating water levels for Congressionally-authorized project purposes. Regulation schedules have been, and will continue to be, designed to balance multiple, and often competing, project purposes and objectives. Managing for better performance of one objective often lessens the effectiveness of performance of competing objectives. For example, for Lake Okeechobee, higher regulation schedules tend to benefit water supply, but may increase the risk to public health and safety, and can harm the ecology of the lake. By contrast, lower lake schedules may produce lake levels more desirable for the lake ecology and improved flood protection, but reduce water supply potential.

Since April 2008, Lake Okeechobee has been operated in accordance with the 2008 Lake Okeechobee Regulation Schedule (2008 LORS). Prior to the 2008 LORS, Lake Okeechobee operations were managed under the "Water Supply and Environment (WSE) Regulation Schedule" since July 2000. The 2008 LORS operational study was initiated to address high lake levels, high estuarine discharges, estuary ecosystem conditions, and lake ecology conditions that occurred during the 2003 to 2005 time period. The study considered the back-to-back historically significant 2004 and 2005 hurricane seasons' effects on the recognized structural integrity issues of HHD along with effects to other project purposes. The 2008 LORS was identified to be effective at decreasing the risk to public health and safety, reducing the number of high-volume discharges to the estuaries, and providing critical flexibility to perform water management operations. When it was approved, LORS 2008 was identified as an interim schedule. The USACE expected to operate under the interim schedule until the earlier of (1) implementation of a new Lake Okeechobee schedule as a component of the system-wide operations to accommodate early CERP projects (Band 1 projects) or (2) completion of the modifications to HHD.

In addition to CERP and non-CERP projects previously specified, the CEPP future without project condition includes implementation of the Everglades Restoration Transition Plan (ERTP) for WCA 3A, ENP, and the SDCS, which replaced the Interim Operational Plan (IOP) for Protection of the Cape Sable Seaside Sparrow (CSSS). From July 2002 through October 2012, WCA 3A was regulated according to a seasonally varying 8.75 to 10.75 feet, NGVD regulation schedule and the Rainfall Plan (initiated in 1985), as per IOP. The primary objective in implementing IOP was to adhere to a 1999 FWS Jeopardy Opinion to reduce damaging high water levels within CSSS habitat west of SRS (i.e. CSSS-A). The purpose of IOP was to provide an improved opportunity for CSSS nesting by maintaining water levels below ground level for a minimum of 60 consecutive days between March 1 and July 15, corresponding to the CSSS breeding season. In addition, a secondary purpose of IOP was to allow CSSS habitat to recover from prolonged flooding

during the mid-1990s. The ERTP superseded the IOP in October 2012 and is intended to define water management operating criteria for the C&SF project features and constructed features of the MWD and Canal-111 South Dade Projects (C-111 SD) until a Combined Operational Plan (COP) is implemented following completion of the MWD and C-111SD projects. ERTP objectives include improving conditions in WCA 3A for the endangered Everglade snail kite, wood stork and wading bird species while maintaining protection for the endangered Cape Sable seaside sparrow (CSSS) and Congressionally-authorized purposes of the C&SF Flood Control project.

Table C.2.2-16. Past, Present, and Reasonably Foreseeable Actions and Plans Affecting the Action Area.

	Past Actions/Authorized Plans	Current Actions and Operating Plans	Reasonably Foreseeable Future Actions and Plans
Status of Non-CERP Projects	- C&SF Project (1948) - ENP Protection and Expansion Act (1989) - Modified Water Deliveries (MWD) General Design Memorandum (GDM) and Final Environmental Impact Statement (1992)	- MWD 8.5 Square Mile Area General Reevaluation Report (2000) - MWD Tamiami Trail Modifications Limited Reevaluation Report (2008) - MWD 8.5 Square Mile Area Interim Operating Criteria Environmental Assessment (2011) - C&SF C-51 West End Flood Control Project - Kissimmee River Restoration - Seepage Barrier near the L-31 N Levee (Miami-Dade Limestone Products Association)	- Tamiami Trail Modifications Next Steps (TTMNS) Project - SFWMD Restoration Strategies Project MWD Closeout -- C-11 South Dade Project (Contracts 8 and 9)
Operations Plan for Lake Okeechobee, WCA 3A, ENP and the South Dade Conveyance System	- Water Supply and Environment (WSE) Lake Okeechobee Regulation Schedule (2000) - Interim Operational Plan* (IOP) 2002 to Present	- Lake Okeechobee Regulation Schedule (LORS 2008) - SFWMD LEC Regional Water Supply Plan - Everglades Restoration Transition Plan (ERTP) October 2012 to present*	- LORS 2008 to be replaced by revised Lake Okeechobee Regulation Schedule - SFWMD periodically revises the LEC Regional Water Supply Interim Plan - ERTP to be replaced by Combined Operational Plan to be completed to include MWD and C-111 components.
CERP Projects		Awaiting Authorization by Congress: - Biscayne Bay Coastal Wetlands Project - Broward County Water Preserve Areas Project - Caloosahatchee River (C-43) West Basin Storage Reservoir - C-111 Spreader Canal Western Project. Congressional Authorization Received and Construction in Progress: - Indian River Lagoon-South Project - Picayune Strand Restoration Project - Site 1 Impoundment Project	- Future CERP Projects

* The 2006 IOP for Protection of the CSSS was the governing regulation schedule for the project area at the start of the CEPP planning process. In addition, existing hydrologic conditions within the project area are a result of IOP operations from 2002 to 2012. Therefore, for planning purposes, the existing

condition includes IOP as the operational plan. The current approved operational plan for southern WCA 3A, ENP, and the SDCS as of October 2012 is known as the ERTP. For planning purposes, the CEPP FWO project condition includes ERTP as the operational plan.

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Table C.2.2-17. Summary of Cumulative Effects.

Hydrology	
Past Actions	Flood and water control projects have greatly altered the natural hydrology.
Present Actions	Federal and state agencies are coordinating on and implementing projects to improve hydrology.
Proposed Action	Reductions in high discharge events from Lake Okeechobee to the Northern Estuaries. Significant beneficial hydrologic effects are anticipated within the Greater Everglades through restoration of sheetflow and rehydration of previously drained areas. Improved hydrologic conditions will result from increasing depths and extending hydroperiods in WCA 3A, WCA 3B, and ENP.
Future Actions	Additional CERP projects propose to restore hydrology to more natural conditions.
Cumulative Effect	Although it is unlikely that natural hydrologic conditions would be fully restored to pre-drainage conditions, improved hydrology would occur. CERP is expected to improve the quantity, quality, timing and distribution of freshwater flow.
Threatened and Endangered Species	
Past Actions	Water management practices and urbanization have resulted in the degradation of existing habitat function and direct habitat loss leading to negative population trends of threatened and endangered species.
Present Actions	Ongoing efforts have been made by Federal and state agencies to implement projects to improve hydrology within the project area. Ongoing projects have been implemented to maintain CSSS populations. The FWS recovery plan is used as a management tool.
Proposed Action	May affect the eastern indigo snake, Florida panther, wood stork, Everglade snail kite, Everglade snail kite critical habitat, Florida manatee, Florida manatee critical habitat, crocodile, crocodile critical habitat, CSSS, CSSS critical habitat, , green sea turtle, leatherback sea turtle, Hawksbill sea turtle, loggerhead sea turtle, Kemp's ridley seat turtle, small tooth sawfish, and small tooth sawfish critical habitat (See **Annex A**).
Future Actions	Ongoing projects would be implemented to maintain threatened and endangered species within the project area. ERTP implementation represents a paradigm shift from single species to multi-species management. ERTP includes performance measures specifically directed at managing water levels and releases for the protection of multiple species and their habitats within the project area.
Cumulative Effect	Habitat improvement, monitoring and management of threatened and endangered species are anticipated to allow populations to be maintained. Improvement of degraded populations is expected to be facilitated by the restoration and enhancement of suitable habitat through efforts to restore more natural hydrologic conditions within the project area.
Fish and Wildlife Resources	
Past Actions	Water management practices have resulted in aquatic vegetation community changes and a resultant disruption of aquatic productivity and function that has had repercussions through the food web, including effects on wading birds, large predatory fishes, reptiles and mammals.
Present Actions	Ongoing efforts have been made by Federal and state agencies to implement projects to improve hydrology within the project area to restore habitat conditions for fish and wildlife resources.
Proposed Action	Negligible effects to fish and wildlife resources within Lake Okeechobee, and the EAA. Reductions in the number of high discharge events to the Northern Estuaries are anticipated to improve suitable habitat for key indicator species such as oysters. Significant beneficial effects are anticipated within the Greater Everglades. Rehydration within previously dry areas of WCA 3A, 3B, and ENP would increase the spatial extent of suitable habitat for several fish and wildlife resources. Increases in forage prey availability (crayfish, other invertebrates, and fish)

	would directly benefit amphibian, reptile, small mammal, and wading bird species. Nesting and foraging activities of resident bird species are anticipated to be significantly improved. Although mammals occurring within the action area are adapted to the naturally fluctuating water levels in the Everglades, there is an increased potential that mammals currently utilizing upland habitat may be negatively affected. Increased freshwater flows to Florida Bay would aid in improving suitable habitat for pink shrimp, juvenile spotted seatrout, sea turtles, manatee and crocodiles among other species.
Future Actions	Some level of improvement to fish and wildlife resources is expected to occur as a result of implementation of projects with the capability of improving the timing, quantity, quality and distribution of freshwater flow to the study area. Hydrologic restoration planned as part of CERP would further improve fish and wildlife habitat.
Cumulative Effect	Habitat improvement efforts are anticipated to benefit fish and wildlife resources.
Vegetation and Wetlands	
Past Actions	Drainage of Florida's interior wetlands, conversion of wetlands to agriculture, and urban development has reduced the spatial extent and quality of wetland resources.
Present Actions	Efforts are being taken by state and Federal regulatory agencies to reduce wetland losses.
Proposed Action	Negligible effects to vegetation within Lake Okeechobee and the EAA are anticipated. Reductions in the number of high discharge events to the Northern Estuaries are anticipated to improve conditions for seagrass beds. Significant beneficial effects are anticipated within the Greater Everglades. Improved hydroperiods and sheetflow within WCA 3A, 3B and ENP would result in reduced soil oxidation, promoting peat accretion necessary to rebuild the complex mosaic of habitats across the landscape. Increased freshwater flows to Florida Bay would aid to lower salinity levels, benefiting mangrove communities and seagrass beds.
Future Actions	Some level of improvement to vegetative communities is expected to occur as a result of implementation of projects with the capability of improving the timing, quantity, quality and distribution of freshwater flow to the study area. More natural hydrology as part of the CERP would assist in restoring natural plant communities.
Cumulative Effect	While the spatial extent of natural plant communities would not be restored to historic proportions, the quality of vegetative communities would be improved.
Cultural Resources	
Past Actions	Flood and water control projects, conversion of wetlands into agriculture and urban development have had adverse unmitigated effects to cultural resources either directly or indirectly.
Present Actions	Ongoing efforts have been made by Federal and state agencies to implement projects to improve hydrology within the project area, thereby stabilizing the tree islands which are known to have a high potential for cultural resources.
Proposed Action	While effects of the proposed action have been evaluated, a final determination of effects on cultural resources is not complete. Consultation with stakeholders, including the State Historic Preservation Office, Advisory Council on Historic Preservation, Seminole Tribe of Florida and the Miccosukee Tribe of Indians of Florida is currently ongoing.
Future Actions	Continued improvement to hydroperiods and sheetflow within WCA 3A, 3B and ENP could reduce soil oxidation, which could stabilize the environment, and this in turn could stabilize tree islands containing cultural resources. Investigations mandated in the Programmatic Agreement for ERTP will be completed (ca. 2016) and will determine the effects of fluctuating water on subsurface historic properties.

Cumulative Effect	Cumulative effects to historic properties and culturally significant sites will potentially be long-term adverse effects if not avoided. Mitigation measures for effects to historic properties could potentially reduce the cumulative effect to minor long-term adverse effects. Mitigation measures for culturally significant sites is unknown.
Water Quality	
Past Actions	Water quality has been degraded from urban, suburban, commercial, industrial, recreational and agricultural development.
Present Actions	Efforts to improve water quality from agricultural areas are ongoing. Federal and state projects can temporarily elevate localized levels of suspended solids and turbidity.
Proposed Action	Implementation of the project is not expected to significantly affect the water quality of Lake Okeechobee or the Northern Estuaries. Changes in the quantity, timing, and distribution of flows within WCA 3A and WCA 3B may result in temporary increases in phosphorus concentrations at some TP Rule monitoring stations; however, this should not significantly affect TP Rule compliance. Over the long-term, distributing the flow over the northern WCA-3A marsh, reducing short-circuiting down the canals, adding more flow from the lake that is treated to the WQBEL, should result in improved water quality within WCA 3 and a reduction in flow weighted mean total phosphorous concentration entering the Park. Southern Estuaries salinity conditions are expected to be improved by the project.
Future Actions	Actions by the State of Florida's Restoration Strategies will decrease nutrient concentration and loadings to the project area. If authorized in the next Water Resources Development Act (WRDA), the Broward County WPA Project, (Record of Decision signed in 2012) would reduce storm runoff deliveries to WCA 3 and improve water quality coming across Tamiami Trail.
Cumulative Effect	While anthropogenic effects on water quality are unlikely to be eliminated, water quality is expected to slowly improve over existing and recent past conditions. During detailed planning and design, the USACE and SFWMD are committed to ensuring that project feature implementation will not result in violations of water quality standards.
Water Supply/Flood Control	
Past Actions	Water supply and flood control for agricultural and urban users has benefited from construction and operation of the C&SF project.
Present Actions	Availability of water from Lake Okeechobee for agricultural users were recently diminished through implementation of LORS 2008. Availability of water for urban and agricultural users were recently diminished through implementation of ERTP. The SFWMD has implemented Restricted Allocation Area Rules to cap users dependent on water supplies from Lake Okeechobee and the regional system (the Everglades).
Proposed Action	Implementation of the project would likely have no effect on water supplies to agricultural users dependent on Lake Okeechobee. Agricultural, municipal, and industrial water supply in LECSA 2 and 3 will increase slightly in the future.
Future Actions	Future supplies would not change in the future unless additional CERP storage or hydrologic improvements to the Everglades are implemented and increase water availability.
Cumulative Effect	While effects on water supplies are unlikely to improve, water supplies available for agricultural and urban users are expected to remain stable until additional storage mechanisms are implemented.

C.2.2.21 References

Acosta, C. A. and S. A. Perry. 2001. Impact of hydropattern disturbance on crayfish population dynamics in the seasonal wetlands of Everglades National Park, USA. Aquatic Conservation: Marine & Freshwater Ecosystems 11:45-57.

Allison, R.V. et al. 1948. Soils, Geology, and Water Control in the Everglades Region, Agriculture Experiment Station. University of Florida, Gainesville, 168 pp.

Armentano, T.V., J.P. Sah, M.S. Ross, D.T. Jones, H.C. Cooley and C.S. Smith, 2006. Rapid responses of vegetation to hydrological changes in Taylor Sough, Everglades National Park, Florida, USA. Hydrobiologia 569: 293-309.

Barry P.J., Doggett C., Anderson R.L., Swain K.M., Sr., (1998), How to evaluate and manage storm damaged forest areas. U.S. Department of Agriculture, Forest Service, Southern Region, Atlanta, GA. Management Bulletin R8-MB 63.

Beerens, James M. 2013. CEPP RSM WADEM Spatial Foraging Conditions Model Output: "WADEM: Wader Distribution Evaluation Modeling". Department of Biological Sciences Florida Atlantic University, Boca Raton, Florida. Report Submitted to U.S. Army Corps of Engineers, 11 March 2013, Cooperative Agreement Number: W912HZ-10-2-0024.

Belwood, J.J. 1992. Florida mastiff bat *Eumops glaucinus floridanus*. Pages 216-223, *in* Rare and Endangered Biota of Florida. Volume I. Mammals, S.R. Humphrey (Ed.), University of Florida Press, Gainesville, Florida, USA.

Bernhardt, C.E. and D.A. Willard. 2006. Marl prairie vegetation response to 20th century hydrologic change. U.S. Geological Survey Open-File Report 2006-1355. U.S. Geological Survey, Eastern Earth Surface Processes Team, 926A National Center, Reston, Virginia, Florida.

Brandt, L.A. and F.J. Mazzotti. 2000. Nesting of the American alligator (Alligator mississippiensis) in the Arthur R. Marshall Loxahatchee National Wildlife Refuge. Florida Field Naturalist. 28(3):122-126.

Brandt, 2013. An Evaluation of Central Everglades Planning Project (CEPP) alternatives using an Index of the crocodile Habitat Suitability Index. U.S. Fish and Wildlife Service, Davie, Florida.

Boyle, R.A., N.J. Dom & M.I. Cook. 2012. Nestling diet of three symapatrically nesting wading bird species in the Florida Everglades. Waterbirds 35:154-159.

Browder, J. A., V. R. Restrepo, J. Rice, M. B. Robblee, Z. Zein-Eldin. 1999. Environmental influences on potential recruitment of pink shrimp, *Farfantepenaeus duorarum*, from Florida Bay nursery grounds. Estuaries 22(2B):484-499.

Browder, J.A., Z. Zein-Eldin, M.C. Criales, M.B. Robblee, and T.L. Jackson. 2002. Dynamics of pink shrimp recruitment in relation to Florida Bay salinity and temperature. Estuaries 25(6B):1335-1371.

Browder, J.S., P.J. Gleason, and D.R. Swift. 1994. Periphyton in the Everglades: spatial variation, environmental correlates, and ecological implications. Pages 379-418, *in* Everglades: The Ecosystem and Its Restoration, S.M. Davis and J.S. Ogden (Eds.). St. Lucie Press, Delray Beach, Florida, USA.

Browder, J. 2013. Browder, J. 2013. CEPP Alternative 4R Lift over FWO. Comparison of Production Index, 1965-2005: Pink Shrimp Model Results. National Marine Fisheries Service, National Oceanic and Atmospheric Administration.

Catano, C. and J. Trexler. 2013. CEPP final model comparison of predicted freshwater fish densities, Draft 4.0.

Chaing, C., C.B. Craft, D.W. Rogers, and C.J. Richardson. 2000. Effect of 4 Years of Nitrogen and Phosphorus Additions on Everglades Plant Communities. Aquatic Botany 68: 61-78.

Chen, M. and Lena Ma, et al. 2001. Arsenic Background Concentrations in Florida Surface Soils: Determination and Interpretation. Environmental Forensics. Vol 2. Pages 117-126.

Conservancy of Southwest Florida. 2009. The Everglades Mink. http://www.conservancy.org/Page.aspx?pid=584.

Cooper , R.M., and J. Roy. 1991. An atlas of Surface Water Management Basins in the Everglades: The Water Conservation Areas and Everglades National Park, South Florida Water Management District, West Palm Beach, 88 pp.

Cottam, C. 1936. Food of the Limpkin. *Wilson Bulletin* 48(1):11–13.

Craft, C. B. and C. Richardson. 2007. Soil Characteristics of the Everglades peatland. Page 59, *in* The Everglades Experiments, Richardson (Ed). Springer 2008.

Craighead, F.C. 1968. The role of the alligator in shaping plant communities and maintaining wildlife in the southern Everglades. Fla. Nat., 41:2-7, 69-74, 94.

Craighead, F.C., Sr. 1971. The trees of south Florida. Volume 1. The natural environments and their succession. University of Miami Press, Coral Gables, Florida, USA.

Curnutt, J.L., A.L. Mayer, T.M. Brooks, L., Manne, O.L., Bass Jr., D.M. Fleming, D.M., M.P. Nott, and S.L. Pimm, 1998. Population dynamics of the endangered Cape Sable seaside sparrow. Animal Conservation 1, 11–21.

Darby, P.C., 1998. Florida apple snail (*Pomacea paludosa* Say) life history in the context of a hydrologically fluctuating environment. Ph.D. Dissertation. University of Florida, Gainesville, Florida, USA.

Darby, P.C., J. D. Croop, R. E. Bennetts, P. L. Valentine-Darby, and W. M. Kitchens. 1999. A comparison of sampling techniques for quantifying abundance of the Florida apple snail (*Pomacea paludosa*, SAY). Journal of Molluscan Studies 65:195-208.

Darby, P.C., R.E. Bennetts, S. Miller, and H.F. Percival. 2002. Movements of Florida apple snails in relation to water levels and drying events. Wetlands 22(3): 489-498.

Darby, P.C., R.E. Bennetts, and H. F. Percival. 2008. Dry down impacts on apple snail (*Pomacea paludosa*) demography: implications for wetland water management. Wetlands 28(1): 204-214.

Davis, S.M., L.H. Gunderson, W.A. Park, J.R. Richardson, and J.E. Mattson. 1994. Landscape dimension, composition, and functioning in a changing Everglades ecosystem. Pages 419-444, *in* Everglades: The Ecosystem and Its Restoration, S.M. Davis and J.C. Ogden (Eds.), St. Lucie Press, Delray Beach, Florida, USA.

Davis, S.M. and J.C. Ogden, 1997. Everglades: the Ecosystem and its Restoration. St. Lucie Press, Delray Beach, Florida, USA.

Dietrich, T.S. 1978. The urbanization of Florida's population; an historical perspective of county growth 1830-1970. Bureau of Economic and Business Research, University of Florida, Gainesville, Florida.

Doren, R.F., J.C. Volin and J.H. Richards. 2009. Invasive exotic plant indicators for ecosystem restoration: An example from the Everglades Restoration Program. *Ecological Indicators*, 9S:S29-S36.

Dorn, N.J., M.I. Cook, G. Hering, R.A. Boyle, J. Nelson & D.E. Gawlik. 2011. Diet variation among white ibis (*Eudocimus albus*) chicks; prey composition depends on recent hydrologic conditions. Ibis depends on recent hydrologic conditions. Ibis 153: 323-335.

Dumas, J. 2000. Roseate Spoonbill (*Ajaia ajaja*). *In* The Birds of North America, No. 306, A. Poole and F. Gill (Eds.). Academy of Natural Sciences, Philadelphia, Pennsylvania and American Ornithologists' Union, Washington, D.C., USA.

Florida Fish and Wildlife Conservation Commission. 2003b. Conservation Strategy for the Black Bear in Florida. Compiled and written by Thomas H. Eason, Ph. D.

Florida Fish and Wildlife Conservation Commission. 2003c. Florida's Breeding Bird Atlas: A Collaborative Study of Florida's Birdlife.

Frederick, P. C. 1997. Tricolored Heron (*Egretta tricolor*). *In* The Birds of North America, No. 306, A. Poole and F. Gill (Eds.). Academy of Natural Sciences, Philadelphia, Pennsylvania and American Ornithologists' Union, Washington, D.C., USA.

Gawlik, D.E., 2002. The effects of prey availability on the numerical response of wading birds. Ecological Monographs 72(3): 329-346.

Gawlik, D. E., G. Crozier, K. H. Tarboton. 2004. Wading bird habitat suitability index. Pages 111-127, *In* K. C. Tarboton, M. M. Irizarry-Ortiz, D. P. Loucks, S. M. Davis, and J. T. Obeysekera. Habitat suitability indices for evaluation water management alternatives. Technical Report, South Florida Water Management District, West Palm Beach, FL.

Golder Associates, 2010. Southeast Renewable Fuels, LLC Air Pollution Permit, FDEP File NO. 05100321-001-AC(PSD-FL-412), RAI Response dated May 13, 2010. http://www.dep.state.fl.us/air/emission/bioenergy/southern_renewables/srf_rai.pdf

Gunderson L. 1994. Vegetation of the Everglades: determinants of community composition. Pages 323-340, *in* Everglades: The Ecosystem and Its Restoration, Davis S and Ogden J (Eds.), St. Lucie Press, Delray Beach, Florida, USA.

Hall, Danielle and Jun Wang. 2010. Presentation at A&WMA International Specialty Conference, Leapfrogging Opportunities for Air Quality, May 2010. http://www.dri.edu/images/stories/editors/leapfrog/techprog/llb_2_Wang.pdf

Holyoak, D. and P.R. Colston. 2003. Limpkin. Pages 212-213, *in* The Firefly Encyclopedia of Birds, Christopher Perrins. Firefly Books.

Humphrey, S.R. and T.L. Zinn. 1982. Seasonal habitat use by river otters and Everglades mink in Florida. Journal of Wildlife Management 46:375-381.

Karunaratne, L.B., P.C. Darby and R.E. Bennetts. 2006. The effects of wetland habitat structure on Florida apple snail density. Wetlands 26(4): 1143-1150.

Kellogg, C. M. and N. J. Dorn. 2012. Consumptive effects of fish reduce wetland crayfish recruitment and drive species turnover. Oecologia 168(4):1111-1121.

Kraemer, G.P., R.H. Chamberlain, P.H. Doering, A.D. Steinman and M.D. Hanisak. 1999. Physiological responses of *Vallisneria americana* transplants along a salinity gradient in the Caloosahatchee Estuary (SW Florida). Estuaries 22:138-148.

Kushlan, J.A. 1990. Wetlands and wildlife, the Everglades perspective in Freshwater wetlands and Wildlife, R. R. Sharitz and J. W. Gibbons (Eds.), CONF-8603101, DOE Symp. Ser. No. 61, Office of Scientific and Technical Information, U.S. Department of Energy, Oak Ridge Tenn.

Kushlan, J.A. and M.S. Kushlan. 1979. Observations on Crayfish in the Everglades, Florida. Crustaceana. Supplement, No. 5, Studies on Decapoda (Biology, Ecology, Morphology,and Systematics):115-120.

Kushlan, J.A. and K.L. Bildstein. 1992. White Ibis. *In* The Birds of North America, No. 2, A. Poole and F. Gill (Eds.). Academy of Natural Sciences, Philadelphia, Pennsylvania and American Ornithologists' Union, Washington, D.C., USA.

Langeland, K. A. 1996. Hydrilla verticillata (L.F.) Royle (Hydrocharitaceae), "The perfect aquatic weed". Castanea 61(3):293-304.

Light, S.S., and J.W. Dineen. 1994. Water Control in the Everglades: A Historical Perspective. Pages 47-84, *in* Everglades: The Ecosystem and Its Restoration, S.M. Davis and J.C. Ogden (Eds.), St. Lucie Press, Delray Beach, Florida, USA.

Lockwood, J.L., M.S. Ross and J.P. Sah. 2003. Smoke on the water: the interplay of fire and water flow on Everglades restoration. Frontiers in Ecology and the Environment 1(9): 462468.

LoGalbo, A., Pearlstine, L., Lynch, J. Alvarado, M. and R. Fennema. 2012. Wood Stork Foraging Probability Index (STORKI v. 1.0). South Florida Natural Resources Conservation Center. Ecosystem Restoration, South Florida Ecosystem Office, Homestead, Florida.

Lorenz, J.J., B.L. Langan-Mulrooney, P.E. Frezza, R.G. Harvey, and Mazzotti, F.J. 2008. Roseate spoonbill reproduction as an indicator for restoration of the Everglades and the Everglades Estuaries. Ecological Indicators 9S:S96-107.

Lorenz, J.J., P.E. Frezza, M. Robinson, L. Canedo, and K. Dyer, 2010. Verification of the predator prey conceptual model for wading birds and aquatic fauna forage base using data from roseate spoonbill studies in Florida Bay. Annual Report: June 2008-May 2009. Unpublished report to the U.S. Army Corps of Engineers, Jacksonville District. Audubon of Florida, Tavernier Science Center, Tavernier, Florida, USA.

Lorenz, J.J., P.E. Frezza, M. Robinson, L. Canedo and K. Dyer. 2009. Verification of the Predator-Prey Conceptual Model for Wading Birds and Aquatic Fauna Forage Base Using Data from Roseate Spoonbill Studies in Florida Bay. Submitted to South Florida Water Management District, West Palm Beach, FL.

Lowther, P. E. and R. T. Paul. 2002. Reddish Egret (*Egretta rufescens*). *In* The Birds of North America, No. 306, A. Poole and F. Gill (Eds.). Academy of Natural Sciences, Philadelphia, Pennsylvania and American Ornithologists' Union, Washington, D.C., USA.

Maehr, D.S. and J.B. Wooding. 1992. Florida black bears *Ursus americanus floridanus*. *In* Rare and Endangered Biota of Florida. Volume 1. Mammals, S.R. Humphrey, (Ed.). University Press of Florida, Gainesville, Florida, USA.

Marks, G.E. and C.S. Marks. 2008. Bat conservation and land management Kissimmee River WMA. Florida Bat Conservancy. Bay Pines, Florida, U.S.A.

Mazzotti, F.J. 1999. The American Crocodile in Florida Bay. Estuaries 22: 552-561.

Mazzotti, F. J. and L. A. Brandt. 1994. Ecology of the American alligator in a seasonally fluctuating environment. Pages 485-505, *in* Everglades: The Ecosystem and Its Restoration, S. M. Davis and J. C. Ogden (Eds.). St. Lucie Press, Delray Beach, Florida, USA.

Mazzotti , F.J. L.A. Brandt, P.E. Moler and M.S. Cherkiss. 2007. American Crocodile (*Crocodylus acutus*) in Florida: Recommendations for Endangered Species Recovery and Ecosystem Restoration. J. Herp. 41: 121-131.

McCormick, P.V., P.S. Rawlik, K. Lurding, E.P. Smith, and F.H. Sklar. 1996. Periphyton water quality relationships along a nutrient gradient in the northern Everglades. Journal of the North American Benthological Society 15:433-449.

McVoy, C. W., W. P. Said, J. Obeysekera, J. A. VanArman and T. W. Dreschel. 2011. Landscapes and Hydrology of the Predrainage Everglades. University Press of Florida, Gainesville, Florida, USA.

Merry, K. L, P. Bettinger, and J. Hepinstall-Cymerman. 2011. A prototype model for estimating the location of forest damage from tropical cyclones. Geographia Technica 2:65-80.

Mitchell, S. J. 2013. Wind as a natural disturbance agent in forests: a synthesis. Forestry 86:147–157.

Moler, P. 1992. American Crocodile population dynamics. Final Report. Study Number: 7532. Bureau of Wildlife Research Florida Game and Fresh Water Fish Commission

NatureServe. 2009. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1 NatureServe, Arlington, Virginia, USA. http://www.natureserve.org/explorer

Newman, S., J. Schuette, J. Grace, K. Rutchey, T. Fontaine, and K. Reddy. 1998. Factors Influencing Cattail Abundance in the northern Everglades. Aquatic Biology 60:265-280.

Newman, S., P.V. McCormick, S.L. Miao, J.A. Laing, W.C. Kennedy, and M.B. O'Dell. 2004. The Effect of Phosphorus Enrichment on the Nutrient Etatus of a Northern Everglades Elough. Wetlands Ecology and Management 12:63-79.

Orth, R. J., T. B. Carruthers, W. C. Dennison, C. M. Duarte, J. W. Fourqurean, K. L. Heck, A. R. Hughes, G. A. Kendrick, W. J. Kenworthy, S. Olyarnik, F. T. Short, M. Waycott and S. L. Williams. 2006. A Global Crisis for Seagrass Ecosystems. BioScience 56(12):987-996.

Parsons, K. C. and T. L. Master. 2000. Snowy Egret (*Egretta thula*). In The Birds of North America, No. 306, A. Poole and F. Gill (Eds.). Academy of Natural Sciences, Philadelphia, Pennsylvania and American Ornithologists' Union, Washington, D.C., USA.

Pearlstine, L., LoGalbo, A., Reynolds, G. 2013. Marl Prairie Indicator Scores. South Florida Natural Resources Center, Everglades National Park, National Park Service. Retrieved July 11, 2013 from http://www.cloudacus.com/simglades/docs/Marl%20Prairie%20Indicator%20scoring28Apr2013.pdf.

Powers, E. 2005. Meta-stable states of vegetative habitats in Water Conservation Area 3A, Everglades. Thesis, University of Florida, Gainesville, Florida, USA.

RECOVER. 2004. CERP Monitoring and Assessment Plan: Part 1. Monitoring and Supporting Research—January 2004. Comprehensive Everglades Restoration Plan, Restoration Coordination and Verification (RECOVER). U.S. Army Corps of Engineers Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, Florida.

Rice, R. W., Gilbert, R.A. and J. M. McCray. 2010. Nutritional Requirements for Florida Sugar Cane. Institute of Food and Agricultural Sciences, University of Florida, Publication SS-AGR-228, Found at: http://edis.ifas.ufl.edu

Rich, E. 1990. Observations of feeding by *Pomacea paludosa*. Florida Scientist 53 (supplement):13.

Richardson, L., C. Hubert, L. Serbina, and L. Racevskis. 2013. Assessment of Ecosystem Service Values for the Central Everglades Planning Project. USGS and University of Florida for USACE.

Rodgers, J.A., Jr. and H.T. Smith. 1995. Little Blue Heron (*Egretta caerulea*). *In* The Birds of North America, No. 306, A. Poole and F. Gill (Eds.). Academy of Natural Sciences, Philadelphia, Pennsylvania and American Ornithologists' Union, Washington, D.C., USA.

Ross, M.S., J.P. Sah, J.R. Snyder, P.L. Ruiz, D.T. Jones, H. Cooley, R. Travieso and S. Robinson. 2004. Effect of hydrological restoration on the habitat of the Cape Sable seaside sparrow. Annual Report of 2003-2004. Unpublished report to U.S. Army Corps of Engineers, Jacksonville, Florida. Southeast Environmental Research Center, Florida International University, Miami, Florida, USA.

Ross, M.S., J.P. Sah, J.R. Snyder, P.I. Ruiz, D.T. Jones, H. Colley, R. Trabieso and D. Hagayari. 2006. Effect of hydrology restoration on the habitat of the Cape Sable seaside sparrow. Annual report of 2005-2005. Unpublished report to the U.S. Army Corps of Engineers, Jacksonville, Florida. Southeast Environmental Research Center, Florida International University, Miami, Florida.

Rutchey, K. and L. Vilchek. 1994. Development of an Everglades Vegetation Map Using a SPOT Image and Global Positioning System. Photogrammetric Engineering and Remote Sensing 60:767-775.

SAFMC. 1998. Final Habitat Plan for the South Atlantic region: Essential Fish Habitat Requirements for Fishery Management Plans of the South Atlantic Fishery Management Council. South Atlantic Fishery Management Council, 1 Southpark Circle, Suite 306, Charleston, SC 29407-4699. 457 pp. plus appendices.

Sah, J.P. 2004. Vegetation structure and composition in relation to the hydrological and soil environments in tree islands of Shark Slough. Pages 85-114 in M.S. Ross and D.T. Jones (eds), Tree Islands in the Shark Slough Landscape: Interactions of Vegetation, Hydrology and Soils. Submitted to Everglades National Park, Homestead, FL.

Sah, J.P., M.S. Ross, J.R. Snyder, P.L. Ruiz, S. Stoffella, M. Kline, B. Shamblin, E. Hanan, D. Ogurcak and B. Barrios. 2008. Effect of hydrological restoration on the habitat of the Cape Sable seaside sparrow. Annual Report of 2006-2007. Report to Everglades National Park, Homestead, FL.

Schaefer, J. and J. Junkin. December, 1990. University of Florida, Florida Cooperative Extension Service. Publication SS-WIS-24: The Eastern Indigo Snake: A Threatened Species. Gainesville, Florida.

Scott, C. 2004. Endangered and Threatened Animals of Florida and their Habitats. University of Texas Press, Austin, Texas, USA.

Sharfstein, B. and A. D. Steinman, 2001. Growth and survival of the Florida apple snail (*Pomacea paludosa*) fed 3 naturally occurring macrophyte assemblages. Journal of the North American Benthological Society: 20(1): 84–95.

Smith, Andrew T. 1980. An environmental study of the Everglades Mink *Mustela vision*. South Florida Research Center Report T-555.

South Florida Natural Resources Conservation Center. 2013a. An Evaluation of Central Everglades Planning Project (CEPP) alternatives using the Alligator Production Suitability Model. Ecosystem Restoration, South Florida Ecosystem Office, Homestead, Florida.

South Florida Natural Resources Conservation Center. 2013b. An Evaluation of Central Everglades Planning Project (CEPP) alternatives using the Wood Stork Foraging Potential Model. Ecosystem Restoration, South Florida Ecosystem Office, Homestead, Florida.

South Florida Natural Resources Conservation Center. 2013c. An Evaluation of Central Everglades Planning Project (CEPP) alternatives using the Everglades Landscape Vegetation Succession

South Florida Water Management District. 2012. South Florida Environmental Report. Volume 1.

South Florida Water Management District. 2011. South Florida Environmental Report. Volume 1. Chapter 3b.

South Florida Water Management District. 2010a. South Florida Environmental Report. Volume 1.

South Florida Water Management District. 2010b. South Dade Wetlands Conceptual Land Management Plan. 2005 – 2010.

South Florida Water Management District. 2009. South Florida Environmental Report. Volume 1.

Steiner, T.M., O.L. Bass, Jr., and J.A. Kushlan. 1983. Status of the eastern indigo snake in southern Florida National Parks and vicinity. South Florida Research Center Report SFRC83/01, Everglades National Park; Homestead, Florida.

Tanner, G.W., J.M. Wood, and R. Hassoun. 1987. Comparative Graminoid Community Composition and Structure within Northern Portions of Everglades National Park, Northeast Shark River Slough, Water Conservation Area 3A, and Water Conservation Area 3B. Unpublished report to U.S. Army Corps of Engineers, Jacksonville District, University of Florida, Gainesville, Florida, USA

Thompson, B. C., J. A. Jackson, J. Burger, L. A. Hill, E. M. Kirsch, and J. L. Atwood. 1997. Least Tern (*Sterna antillarum*). *In* The Birds of North America, No. 306, A. Poole and F. Gill (Eds.). Academy of Natural Sciences, Philadelphia, Pennsylvania and American Ornithologists' Union, Washington, D.C., USA.

Trexler, J. C., Loftus, W. F., Jordan, F., Lorenz, J. J., Chick, J. H., & Kobza, R. M. (2000). Empirical assessment of fish introductions in a subtropical wetland: an evaluation of contrasting views. *Biological Invasions*, *2*(4), 265-277.

Troxler, T.G. and J.H. Richards. 2009. δ13C, δ15N, carbon, nitrogen and phosphorus as indicators of plant ecophysiology and organic matter pathways in Everglades deep slough, Florida. Aquatic Botany 91: 157-169.

Troxler, T.G., and D.L. Childers. 2010. Biogeochemical contributions of tree islands to Everglades wetland landscape nitrogen cycling during seasonal inundation. Ecosystems 13:75-89.

Turner, R. L. 1996. Use of stems of emergent vegetation for oviposition by the Florida apple snail (*Pomacea paludosa*), and implications for marsh management. Florida Scientist 59:34–49.

U.S. Army Corps of Engineers. 1999. Central and Southern Florida Project Comprehensive Review Study: Final Integrated Feasibility Report and Programmatic Environmental Impact Statement. Jacksonville District, Jacksonville, Florida, USA.

U.S. Army Corps of Engineers. 2007. Lake Okeechobee Regulation Schedule, Final Supplemental Environmental Impact Statement, November 2007. Jacksonville District, Jacksonville, Florida.

U.S. Environmental Protection Agency. 2002. Median Life, Annual Activity and Load Factor Values for Nonroad Engine Emissions Modeling, USEPA420-P-02-014.

U.S. Environmental Protection Agency. 2008. Final Total Maximum Daily Load (TMDL) for Biochemical Oxygen Demand, Dissolved Oxygen, and Nutrients in the Lake Okeechobee Tributaries. USEPA Region 4, Atlanta, GA. June 2008.

U.S. Fish and Wildlife Service. 1999. South Florida Multi-Species Recovery Plan. Southeast Region, Atlanta, Georgia, USA.

U.S. Fish and Wildlife Service. 2010. Eco-recommendations for the multi-species schedule. Presentation to the ERTP Team. January 15, 2010. Vero Beach, Florida, USA.

Van der Walk, A.G., L. Squires, and C.H. Welling, 1994. Assessing the impacts of an increase in water levels on wetland vegetation. Ecological Applications 4: 525-533.

Wetzel, R.G. (Ed.). 1983. Periphyton of Freshwater Ecosystems. W. Junk Publishers, Boston, Massachusetts, USA.

Wetzel, P. R. 2002. Tree island ecosystems of the world. In: Sklar FH, van der Valk AG (eds) Tree islands of the Everglades. Kluwer Academic Publishers, Dordrecht.

Wetzel, P.R., A.G. van der Valk, S. Newman, C.A. Coronado, T.G. Troxler-Gann, D.L. Childers, W.H. Orem, F.H. Sklar. 2009. Heterogeneity of phosphorous distribution in a patterned landscape, the Florida Everglades. Plant Ecology 200:69-82.

Wetzel, P.R., F.H. Sklar, C.A. Coronado, T.G. Troxler, S.L. Krupa, P.L. Sullivan, S. Ewe and S. Newman. 2011. Biogeochemical processes on tree islands in the Greater Everglades: Initiating a new paradigm. Critical Reviews in Environment and Technology 41:670-701.

Wood, J.M. and G.W. Tanner, 1990. Graminoid community composition and structure within four everglades management areas. Wetlands 10(2): 127-149.

Zaffke, M. 1983. Plant communities of Water Conservation Area 3A: Baseline Documentation Prior to Operation of S-339 and S-340. South Florida Water Management District, West Palm Beach, Florida, USA.

Zweig, C.L., 2008. Effects of landscape gradients on wetland vegetation. Ph.D. Dissertation. University of Florida, Gainesville, Florida, USA.

Zweig, C.L. and W.M. Kitchens, 2008. Effects of landscape gradients on wetland vegetation communities: information for large-scale restoration. 2008. Wetlands 28(4): 1086-1096.

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COMPREHENSIVE EVERGLADES RESTORATION PLAN, CENTRAL EVERGLADES PLANNING PROJECT, INTEGRATED PROJECT IMPLEMENTATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT: FINAL JULY 2014, REVISED DECEMBER 2014

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