SFHS Meeting
Coral Springs, FL
May 8th, 2013

HERBERT HOOVER DIKE REHABILITATION "THE IMPORTANCE OF DAM SAFETY IN SOUTH FLORIDA"

Presented By:

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SOUTH FLORIDA HYDROLOGIC SOCIETY

PRESENTATION OUTLINE

- USACE Dam Safety Program
- HHD History
- Cutoff Wall Design
- CSM Method
- QA/QC
- Data Management

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USACE DAM SAFETY PROGRAM

- Risk & Reliability-based approach adopted since early 2000s to manage portfolio of 694 dams in US & PR
- Public safety the number one priority
- Flood damage to levees during the Katrina disaster gave new urgency to addressing the aging infrastructure Corps portfolio of dams and levees

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USACE DAM SAFETY PROGRAM

- Approximately 15 million people are at risk from USACE dams
- Program adopted to develop balanced and informed assessments
- Evaluate, prioritize and justify dam safety decisions

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USACE DAM SAFETY PROGRAM

- Approximately 95 percent of the dams managed by USACE are more than 30 years old
- 52 percent have reached or exceeded the 50-year service life
- $25 billion a year in economic benefits
- The 2013 National Inventory of Dams database is now available!

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DAM SAFETY ACTION CLASSIFICATION

Table 3.1 USACE Dam Safety Action Classification Table* 6 May 2008 version

Dam Safety Action Class		Characteristics of this class	Actions for dams in this class
I **URGENT AND COMPELLING** (Unsafe)		**CRITICALLY NEAR FAILURE** Progression toward failure is confirmed to be taking place under normal operations. Almost certain to fail under normal operations from immediately to within a few years without intervention. **OR EXTREMELY HIGH RISK** Combination of life or economic consequences with probability of failure is extremely high.	Take immediate action to avoid failure. Validate classification through an external peer review. Implement interim risk reduction measures, including operational restrictions, and ensure that emergency action plan is current and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Expedite investigations to support justification for remediation using all resources and funding necessary. Initiate intensive management and situation reports.
II **URGENT** (Unsafe or Potentially Unsafe)		**FAILURE INITIATION FORESEEN** For confirmed (unsafe) and unconfirmed (potentially unsafe) dam safety issues, failure could begin during normal operations or be initiated as the consequence of an event. The likelihood of failure from one of these occurrences, prior to remediation, is too high to assure public safety. **OR VERY HIGH RISK** The combination of life or economic consequences with probability of failure is very high.	Implement interim risk reduction measures, including operational restrictions as justified, and ensure that emergency action plan is current, and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Expedite confirmation of classification. Give very high priority for investigations to support justification for remediation.
III **HIGH PRIORITY** (Conditionally Unsafe)		**SIGNIFICANTLY INADEQUATE OR MODERATE TO HIGH RISK** For confirmed and unconfirmed dam safety issues, the combination of life, economic, or environmental consequences with probability of failure is moderate to high.	Implement interim risk reduction measures, including operational restrictions as justified, and ensure that emergency action plan is current and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Prioritize for investigations to support justification for remediation considering consequences and other factors.
IV **PRIORITY** (Marginally Safe)		**INADEQUATE WITH LOW RISK** For confirmed and unconfirmed dam safety issues, the combination of life, economic, or environmental consequences with probability of failure is low and may not meet all essential USACE guidelines.	Conduct elevated monitoring and evaluation. Give normal priority to investigations to validate classification, but no plan for risk reduction measures at this time.
V **NORMAL** (Adequately Safe)		**ADEQUATELY SAFE** Dam is considered safe, meeting all essential USACE guidelines with no unconfirmed dam safety issues. **AND RESIDUAL RISK IS CONSIDERED TOLERABLE.**	Continue routine dam safety activities, normal operation, and maintenance.

* At any time for specific events a dam, from any action class, can become an emergency requiring activation of the emergency plan

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USACE PARTNERS

- Institute for Water Resources
- Bureau of Reclamation
- Federal Energy Regulatory Commission
- ASDSO
- US Society of Dams
- Association of Engineering Geologists

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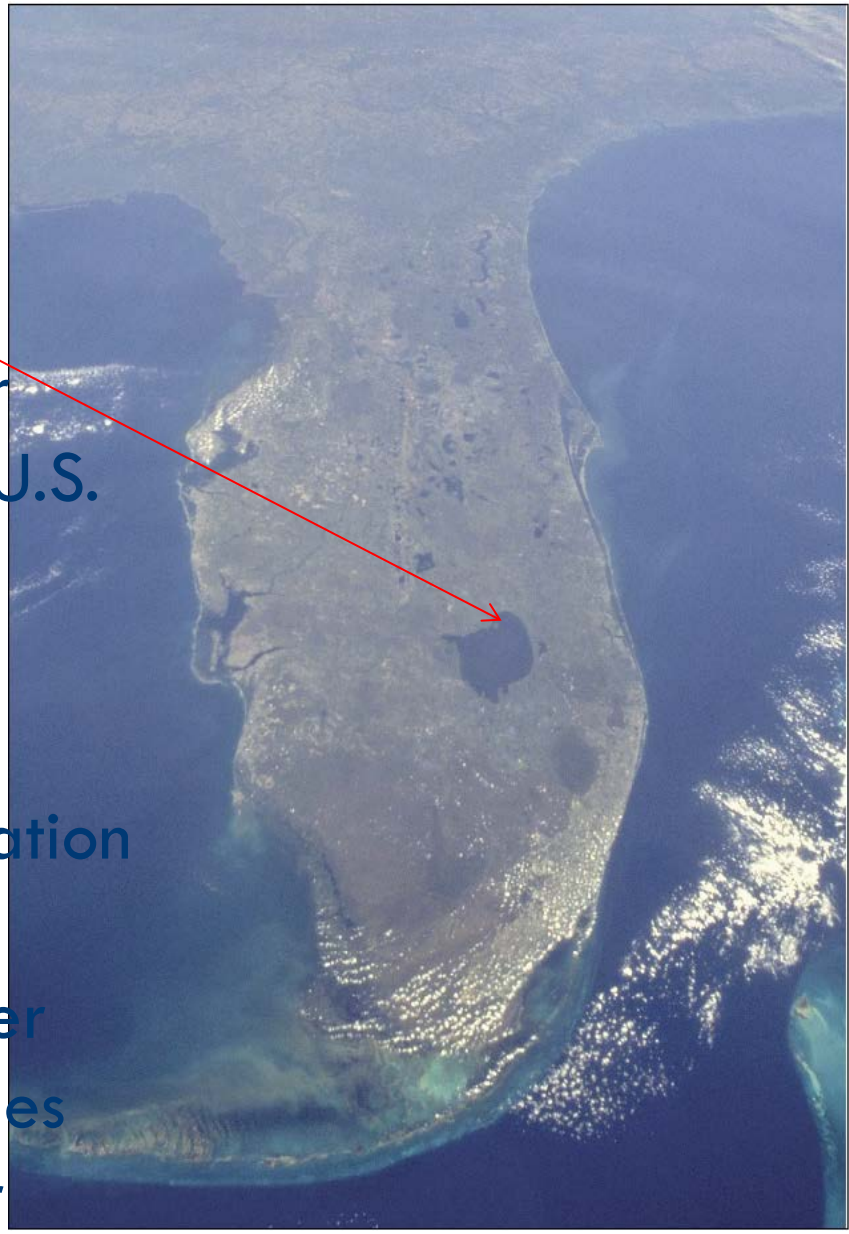
Lake Okeechobee

- 730 mi^2
- 2nd Largest Freshwater
- Lake w/in continental U.S.
- Depth ~12 feet
- 154 mile cross-state waterway
- Drinking Water & Irrigation
- Recreation
- 143-mile dike built after 1926 & 1928 Hurricanes
- Changed natural water flow



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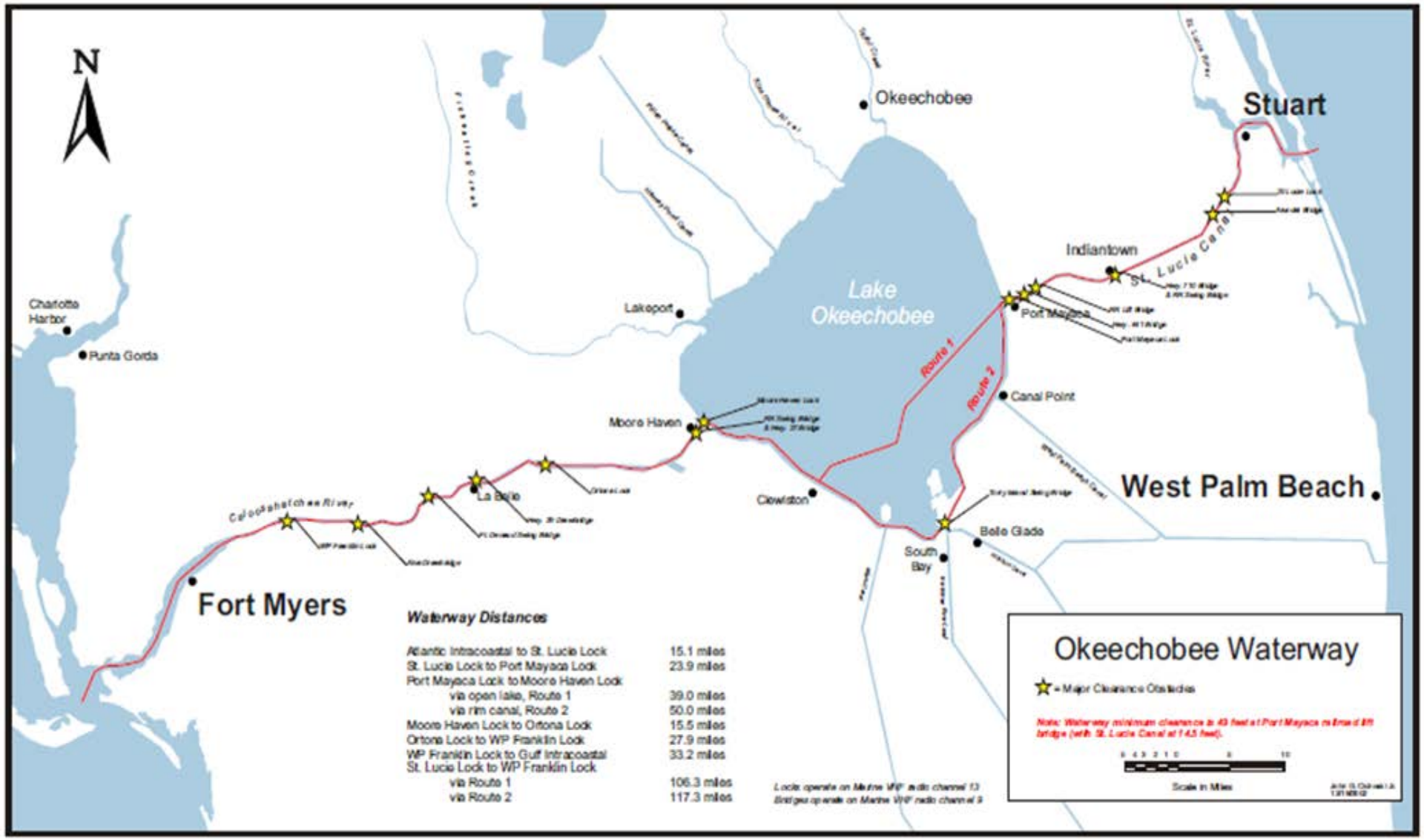
OKEECHOBEE WATERWAY

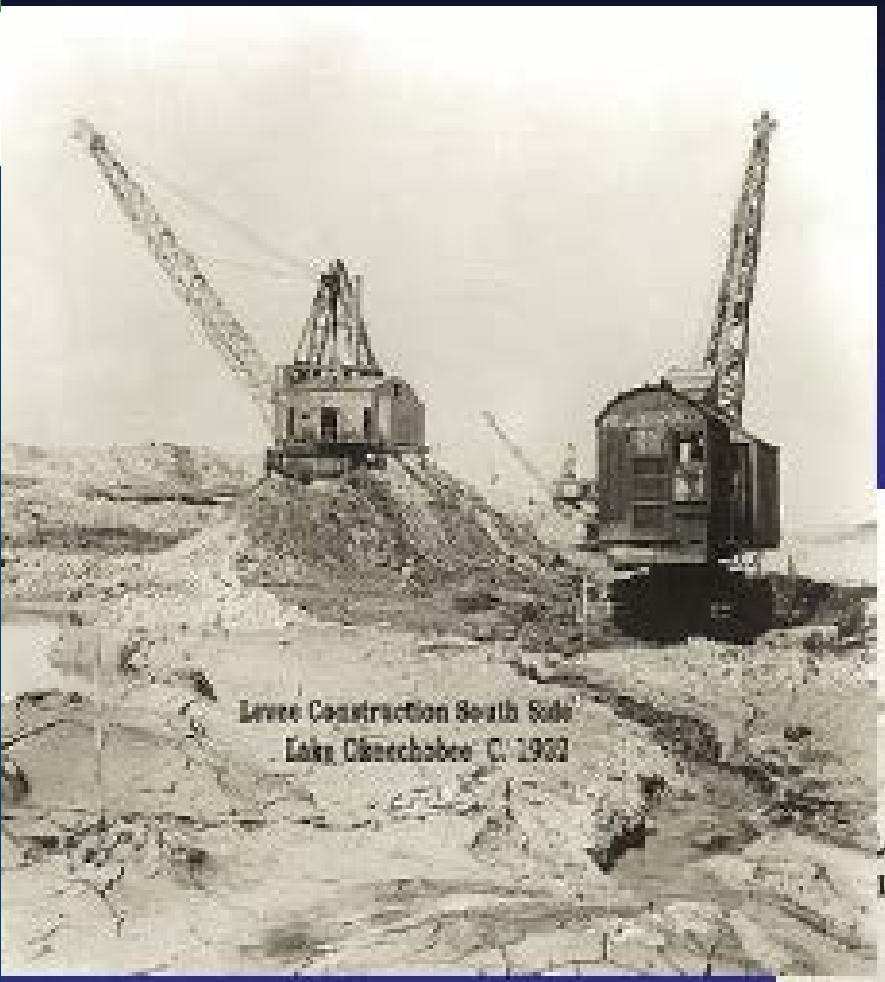


History Of Dike Construction

Great Miami Hurricane
*Great Okeechobee / San Felipe Hurricane**

The River and Harbor Act of 1930 authorized construction of 67.8 miles of levee along the south shore and 15.7 miles of levee along the north shore of Lake Okeechobee.

1930's – 1960's



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CONSTRUCTION FLAWS

- No selection of fill materials or use of engineered fill placement techniques
- No seepage control features through embankment or foundation
- Ditches on both sides of the dike exposed high porosity foundation
- Were no Dam Safety Standards in 1932

FIG. 2
SERIOUS EROSION ON UNPROTECTED LEVEE FACE

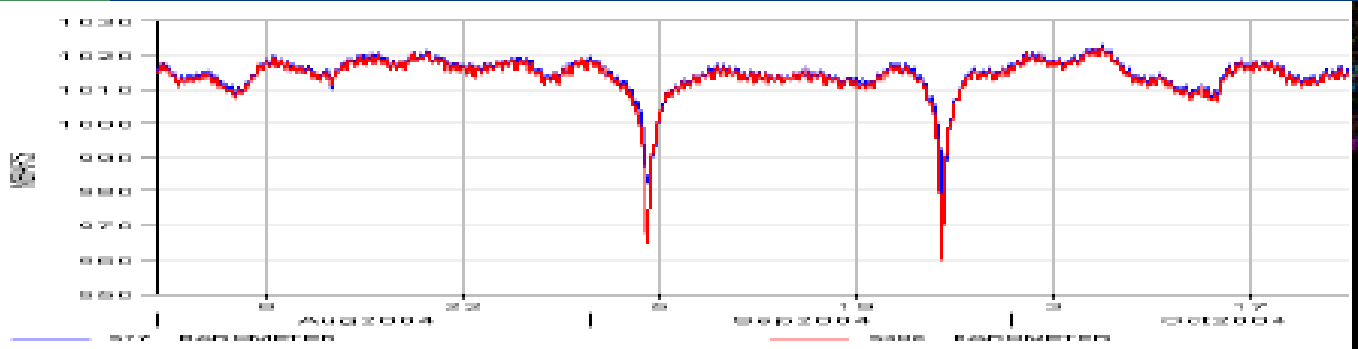
NOTE:

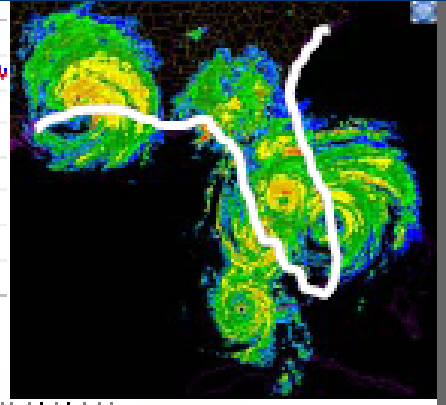
LEVEE EROSION ABOUT MIDWAY BETWEEN HURRICANE GATE STRUCTURES NOS. 2 AND 3, CAUSED BY THE HURRICANE OF SEPTEMBER 17, 1947.

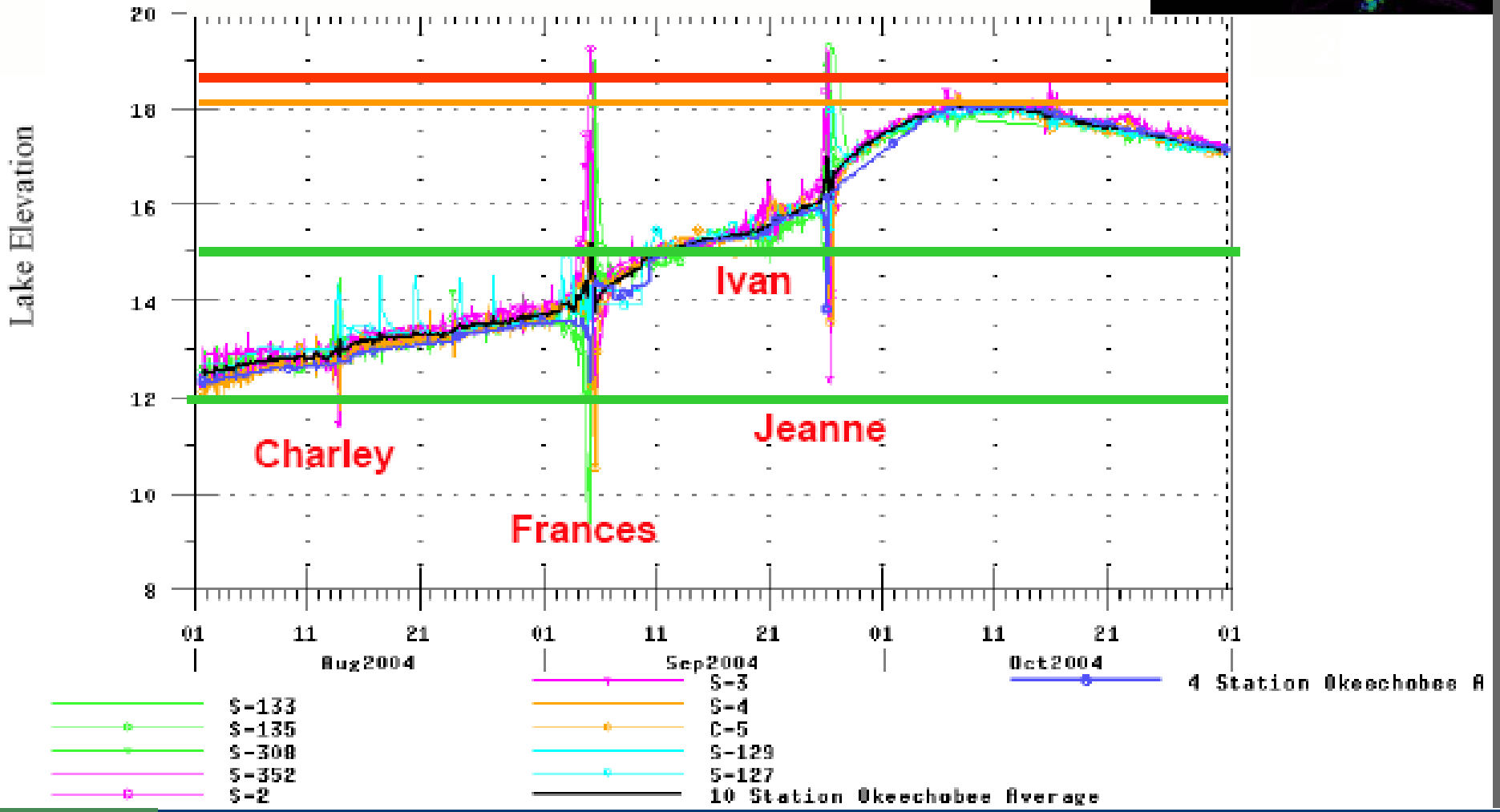
CENTRAL AND SOUTHERN FLORIDA
LAKE OKEECHOBEE

LEVEE EROSION - 1947 HURRICANE

JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
TO ACCOMPANY PARTIAL DFR, PART IV, SUPP. 2,
DATED: APRIL 27, 1954 SEC. 4
FILE NO: 400-22,516


mb
1030
1020
1010
1000
990
980
970
960
950
Aug2004
Sep2004
Oct2004




Lake Elevation
20
18
16
14
12
10
8
01
11
21
01
11
21
01
11
21
01
Aug2004
Sep2004
Oct2004
Ivan
Jeanne
Charley
Frances
S-133
S-135
S-308
S-352
S-2
S-3
S-4
C-5
S-129
S-127
10 Station Okeechobee Average
4 Station Okeechobee A

Hurricane Katrina Alters Risk Management Approach

Hurricane Katrina strikes land Aug 29, 2005

- World-wide impact, re-evaluation of projects
- Corps changes procedures for managing dams and levees
- Interagency Task Force Report recommends *robustness, resiliency and redundancy* for all dams

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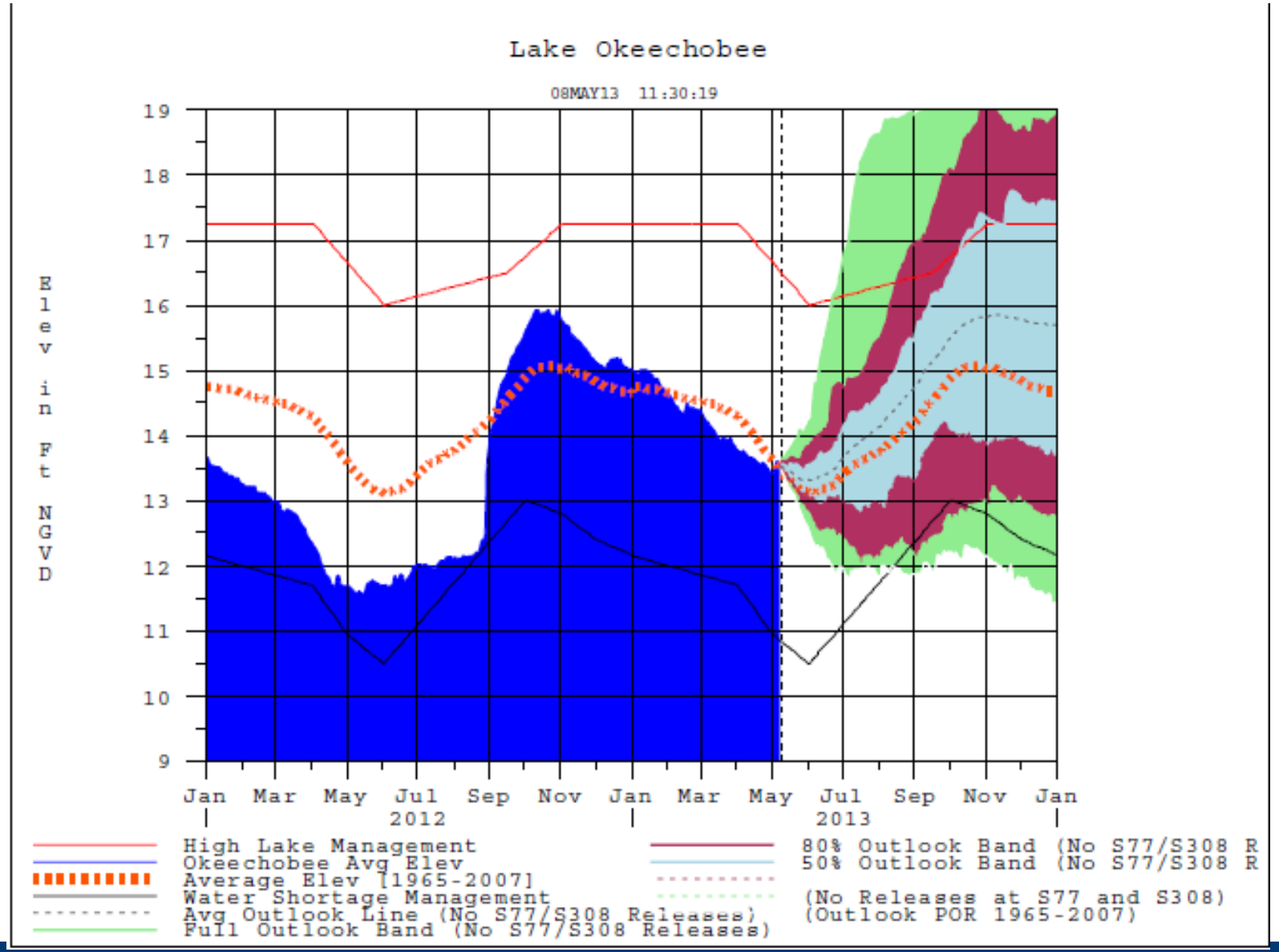
CURRENT LAKE LEVEL



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Herber Hoover Dike Rehabilitation Project

US Army Corps of Engineers

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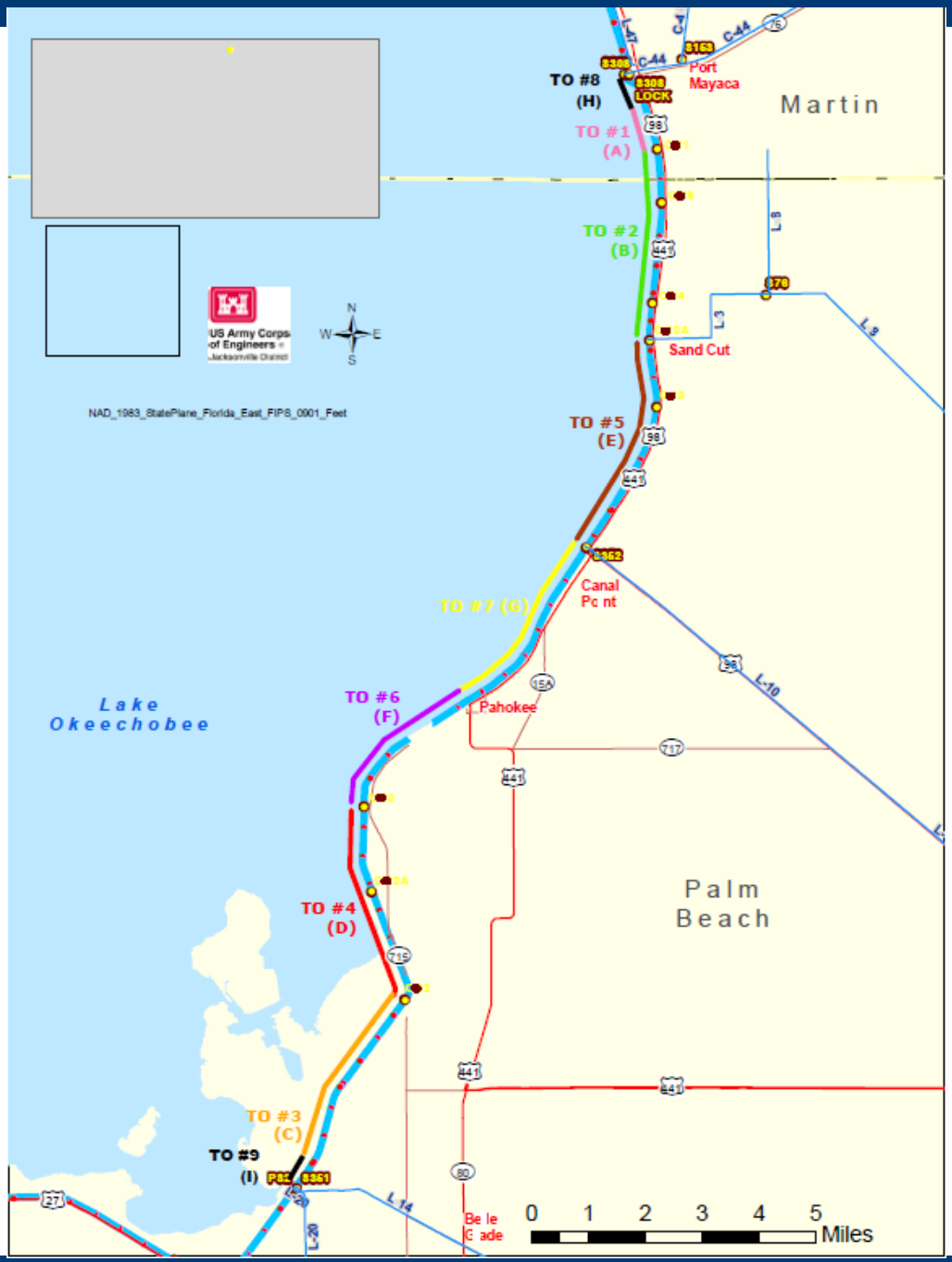
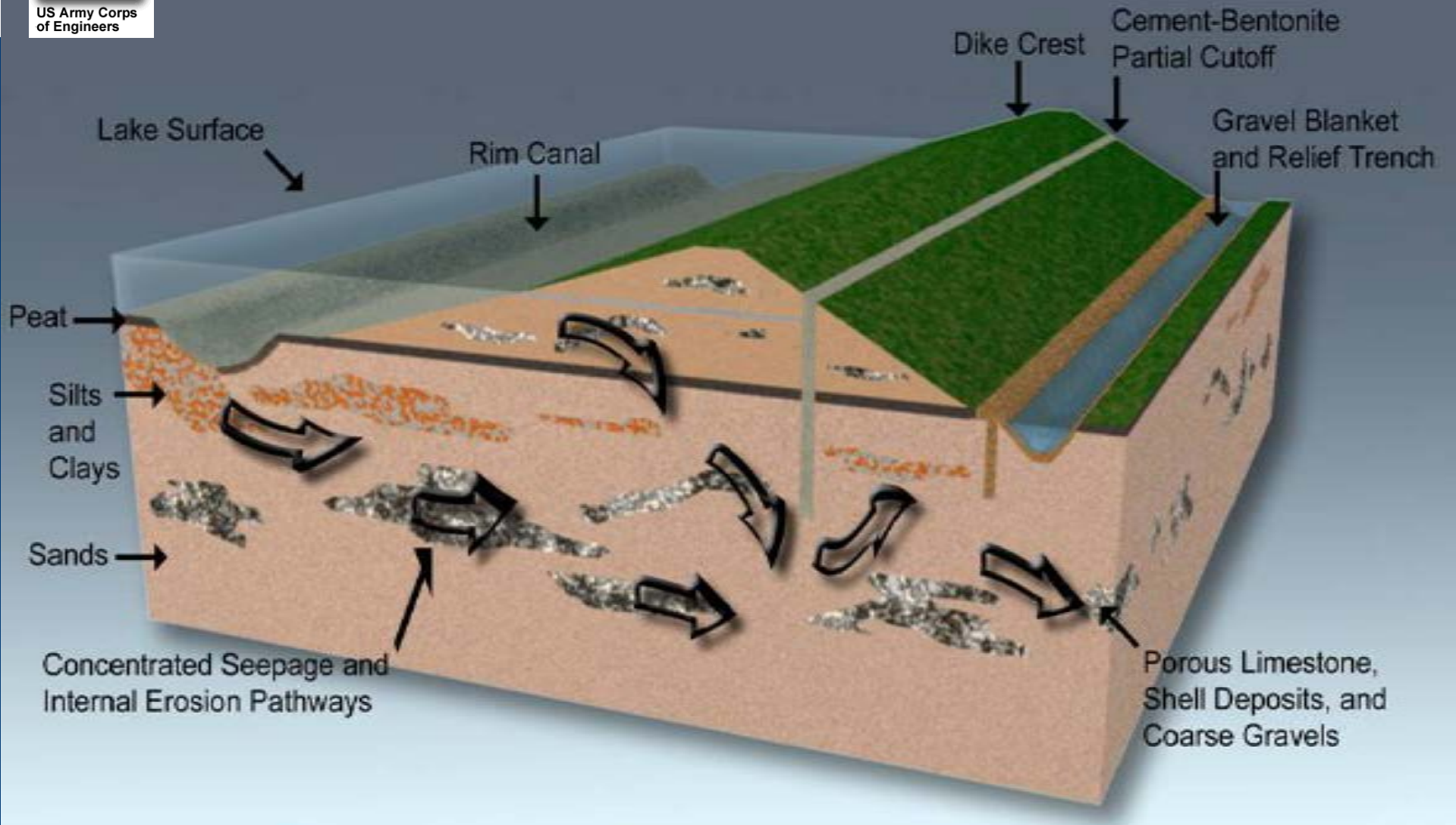


US Army Corps of Engineers



Proposed Repair, Herbert Hoover Dike

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Installation of Deep Cutoff Wall Using the Cutter Soil Mixing Method

Cutoff Wall Considerations

Cutoff Wall Cost Comparison			
Cutoff Wall Type	Average Cost ($/square feet)	Number of Capable Technologies	Cost per mile ($/mile)
Partial cutoff wall (80 feet)	$24	7	$10,000,000
Full depth cutoff wall (200 feet)	$100 to $250	2	$106,000,000 to $264,000,000

- A partial cutoff wall is more cost effective in reducing seeps and pipes
- Both walls require landside features for relief of uplift pressure
- A fully penetrating cutoff wall will stop seepage and impact the regional groundwater supply; additional features needed to provide water supply

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PERFORMANCE CRITERIA

- Continuous CB Wall
- Panel Width < 34 in (25 in)
- Avg. CSM Panel Depth 70 ft
- UC Strength 100 – 500 psi
- K = 1x 10^{-6} cm/sec or less

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BAUER BG 28

Pre-Drilling Activities

Cutter Soil Mixer (CSM)

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Cutter Soil Mixing

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Construction Quality Control Procedures

- Daily CQC reporting
- Bulk Sampling
- Post Placement Sampling
- Verification Core Drilling
- Inclinometer Testing
- Video Logging
- Falling Head Permeability Field Tests
- Unconfined Compressive Strength Tests

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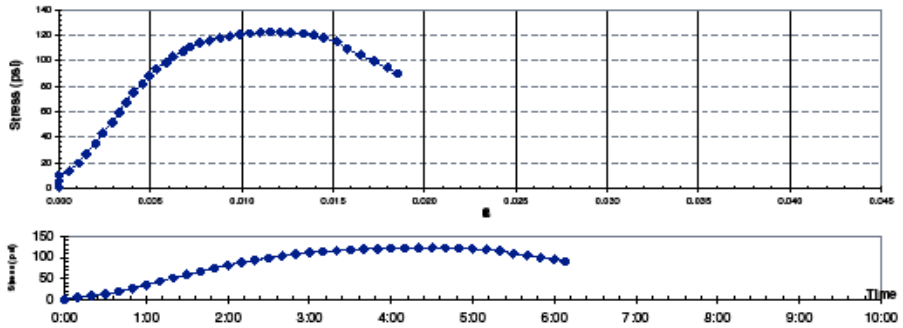
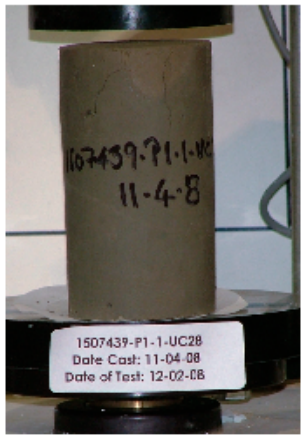
WILLIAMS EARTH SCIENCES

Unconfined Compressive Strength ASTM D2166-06

Herbert Hoover Dike - Reach 1, Task 2

Main Identification:	1507439-P1-1			Depth (ft):	-		
Sub Identification:	1507439-P1-1-UC28			Elev (ft):	-		
Description:	UCC1507439-P1-1UC28.txt			Curing Time (days):	28		
Date Tested:	12/2/2008	Date Cast:	11/4/2008	Appraratus:	Durham Geo S-611 WES#002013		
Technician:	LD			Average D (in):	3.013	L/D:	1.810
Diameter D(in):	3.008	3.004	3.029	Average L (in):	5.455	Correction Factor:	0.980
Height L(in):	5.460	5.456	5.449	Area (in2):	7.131	UC (psi):	122.5
Total Weight (gr):	1262.4	Dry Weight (gr):	1016.3	Moisture (%):	24.2	Corrected UC (psi):	120.1
Test time (min)	6:08	Fail time (min):	4:20	Dry Density (pcf):	99.54	Shear Strength (psi):	60.1
Remarks:	Density obtained after shear; No cap; Storage per ASTM D4832; Run per ASTM D2166					Failure e (%):	1.155
						Strain Rate (%/min):	0.267





Keith Bennett, P.E.
Senior Geotechnical Engineer
Florida Registration No. 33075

- Unconfined Compressive Strength
- ASTM D2166

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Boring Designation 1504506

WILLIAMS EARTH SCIENCES

VERIFICATION BORING LOG

DIVISION	INSTALLATION	SHEET 1 OF 3 SHEETS
Jacksonville		

PROJECT	Herbert Hoover Dike Demonstration section 1504+50.6
BORING DESIGNATION	1504506
LOCATION COORDINATES	X= -1.9 Y= -0.3
DRILLING AGENCY	Williams Earth Sciences
CONTRACTOR FILE NO.	
DEPTH OF BORING (ft)	55
NAME OF DRILLER	Jim Spoon
SIZE & TYPE OF BIT	Diamond Stepbit Bottom Dish
TYPE OF DRILL RIG	CME 850
TOTAL NUMBER CORE BOXES	5
ELEVATION GROUND WATER	14.33 (assumed based on reported lake level)
DATE BORING START	11/18/08 COMPLETED 11/18/08
ELEVATION TOP OF BORING	35.14
MAX SAMPLE LENGTH (in)	60
CORE SAMPLE DIAMETER (in)	3.3
BOREHOLE LOGGER:	Gabrielle Enos

ELEV.	DEPTH	MATERIAL DESCRIPTIONS & NOTES	BOX #	GEAR	PRESS. (psi)	RPM	TIME (min:sec)	REC (%)	RQD (%)	Qu (psi)	PICTURE
35.1	0	No samples collected in upper 5 feet. Top of wall begins at 5 ft bls									
30.1	5	Dark greenish-grey cementious soil with shell inlusions	1	2nd	200	60	0:2	100	95		
				2nd	200	60	4:30				
				2nd	200	60	4:42				
				2nd	200	60	4:34				
				2nd	200	60	4:58				
25.1	10	Dark greenish-grey cementious soil with shell inlusions hard drilling at 3 feet into run	1	2nd	200	60	8:24	100	100		
				2nd	200	60	9:24				
				2nd	200	60	13:19				
				2nd	200	60	5:17				
				2nd	200	60	6:15				
20.1	15	Dark greenish-grey cementious soil with shell inlusions UCC Sample at 17-18 ft bls	2	2nd	200	60	3:54	100	100	757.1 844.6	
				2nd	200	60	4:22				
				2nd	200	60	4:01				
				2nd	200	60	4:33				
15.1	20			2nd	200	60	5:04				

❖Verification Coring & Photo Log

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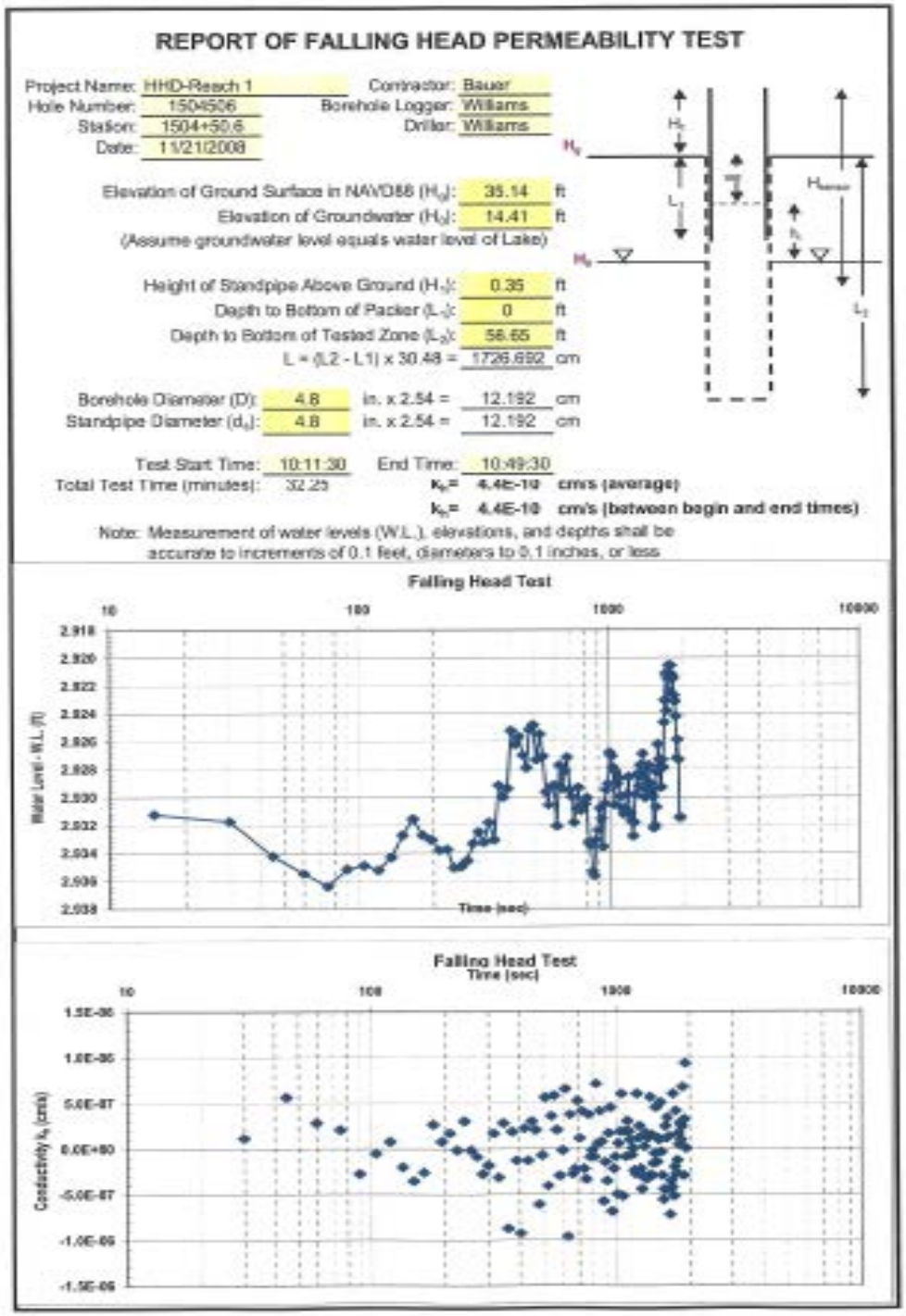
2008 11 24



REPORT OF FALLING HEAD PERMEABILITY TEST

Project Name: HHD-Reach 1 Contractor: Bauer
Hole Number: 1504506 Borehole Logger: Williams
Station: 1504+50.6 Driller: Williams
Date: 11/21/2008

Elevation of Ground Surface in NAVD88 (H_g): 35.14 ft
Elevation of Groundwater (H_g): 14.41 ft
(Assume groundwater level equals water level of Lake)

Height of Standpipe Above Ground (H_s): 0.35 ft
Depth to Bottom of Packer (L_1): 0 ft
Depth to Bottom of Tested Zone (L_2): 56.65 ft
L = (L2 - L1) x 30.48 = 1726.692 cm

Borehole Diameter (D): 4.8 in. x 2.54 = 12.192 cm
Standpipe Diameter (d_s): 4.8 in. x 2.54 = 12.192 cm

Test Start Time: 10:11:30 End Time: 10:49:30
Total Test Time (minutes): 32.25

k_h= 4.4E-10 cm/s (average)
k_h= 4.4E-10 cm/s (between begin and end times)

Note: Measurement of water levels (W.L.), elevations, and depths shall be accurate to increments of 0.1 feet, diameters to 0.1 inches, or less

- Open Hole Falling Head Permeability Tests
- Vibrating Wire Piezometer

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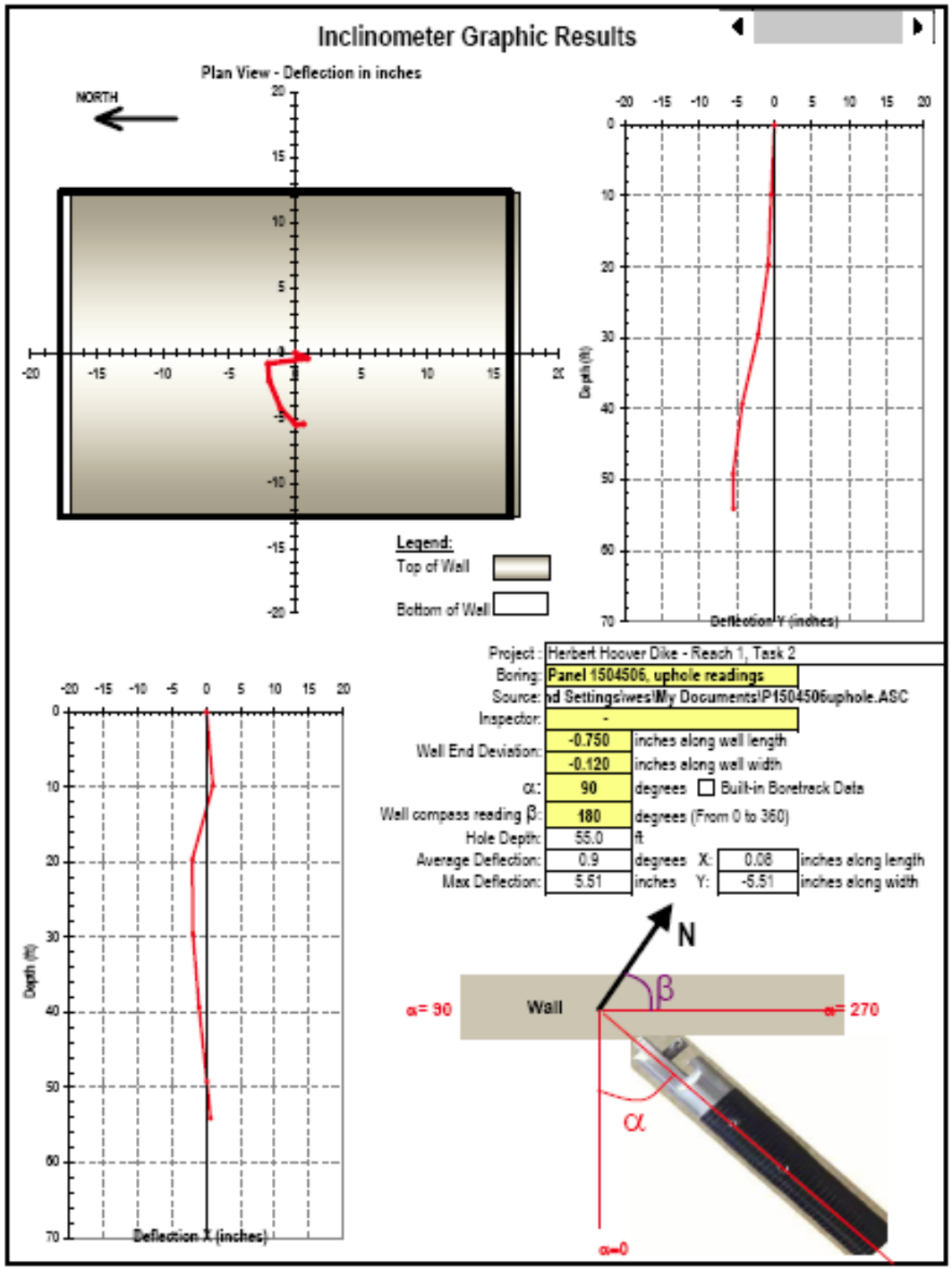

❖Inclinometer Measurement

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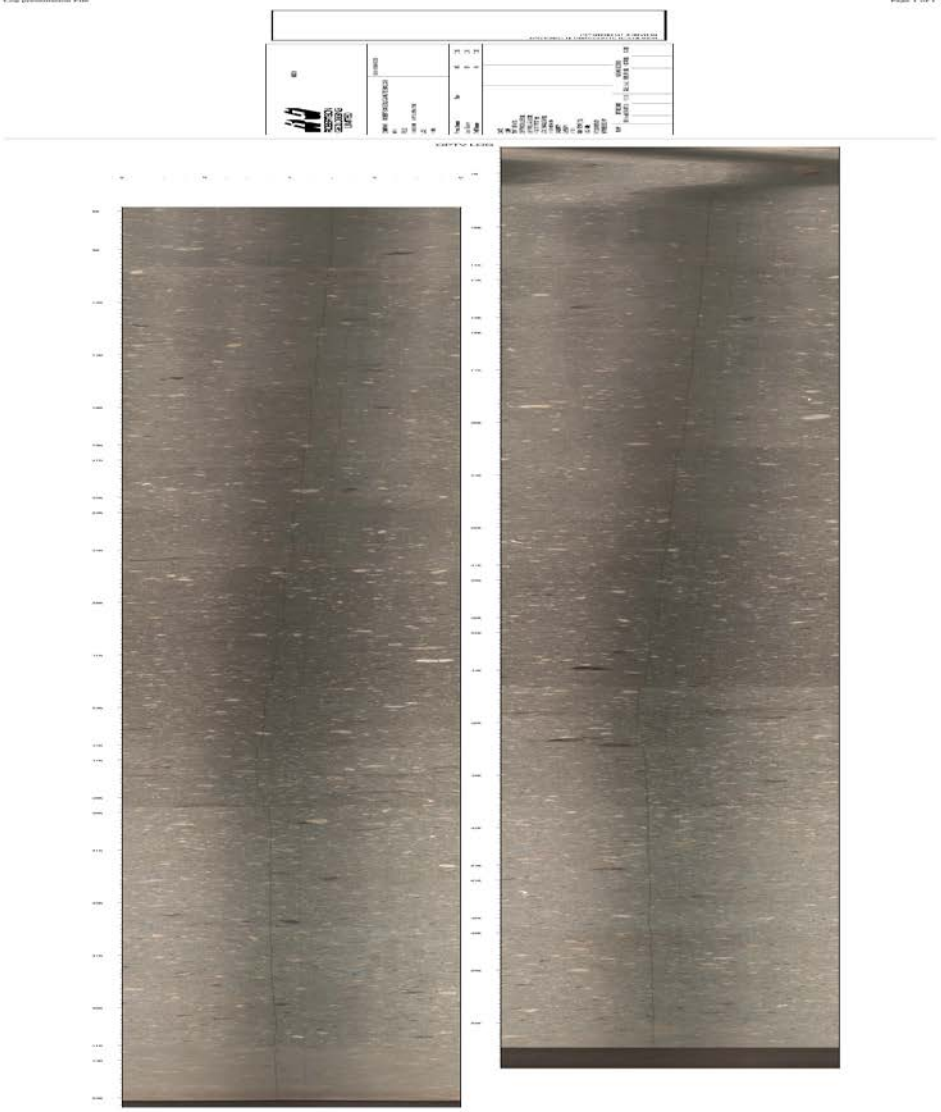

- Downhole Video Log
- 360 degree view

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DATA MANAGEMENT

- Collection and transmission of data
- Remote sites with complex instrumentation and onerous construction QC requirements
- Automated Data Management Systems
- GIS integration
- Web Based Information Management System

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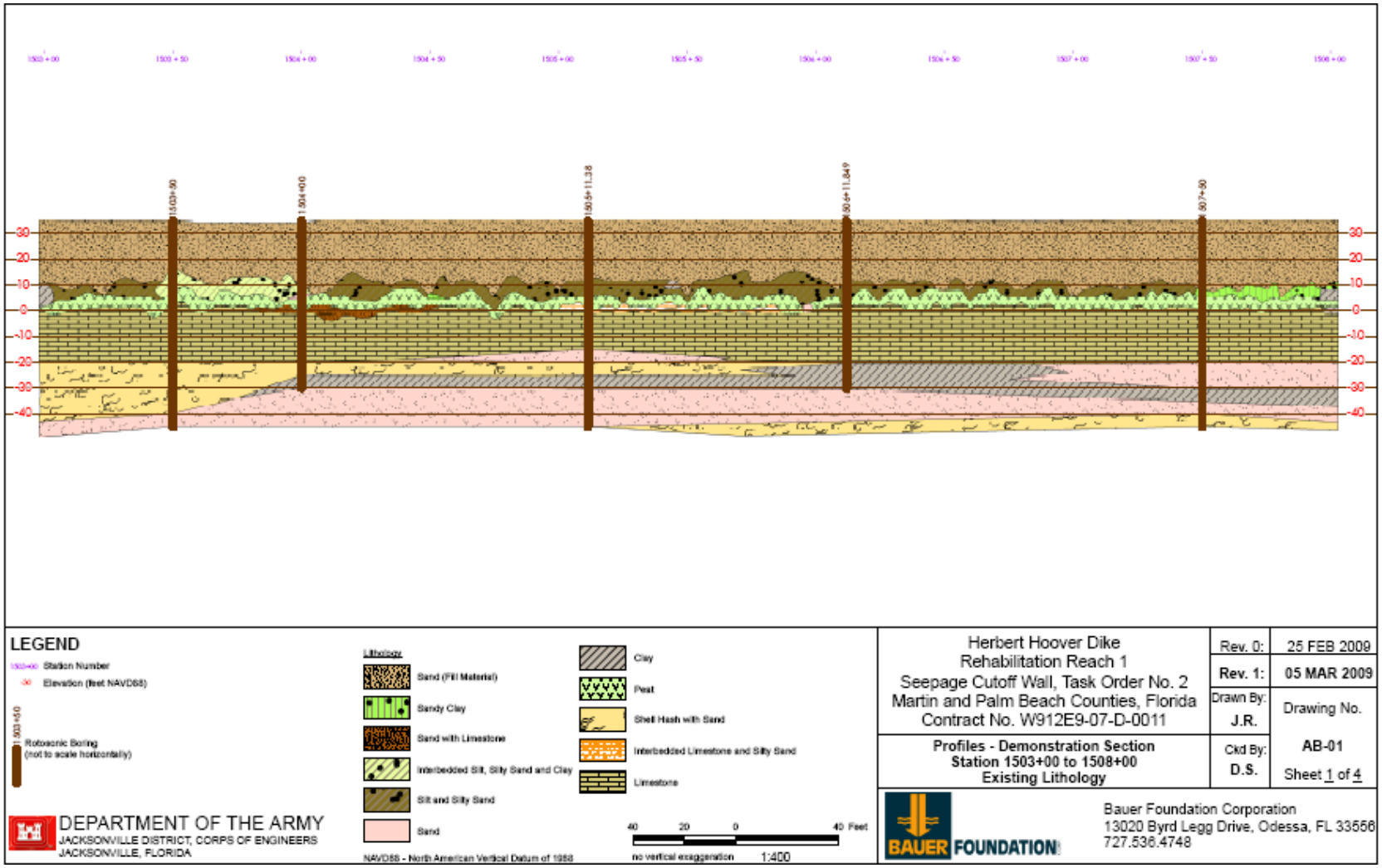
walltracker



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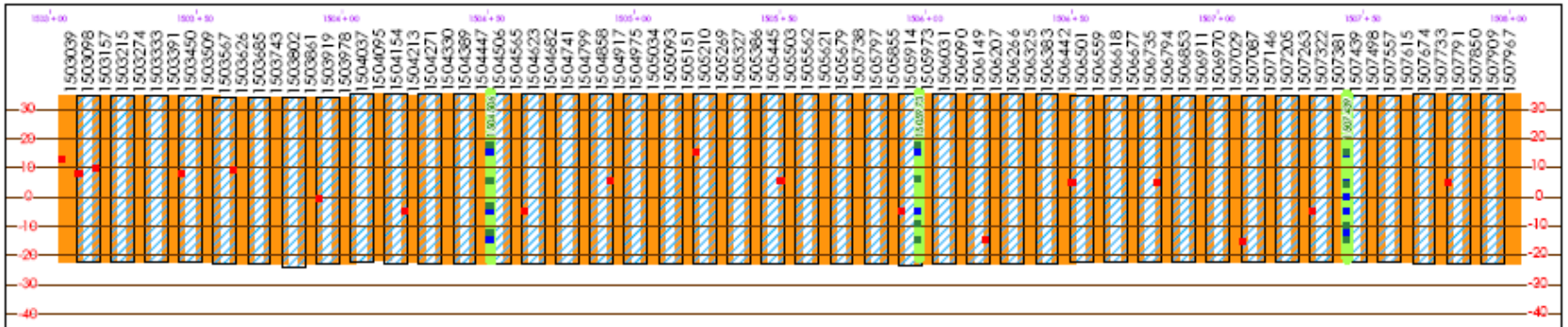
BAUER FOUNDATION CORP.

walltracker



Laboratory Results:

Demonstration Section Station 1503+00 to 1508+00 - Daily Bulk Sample Summary

Sample ID	Panel Type	Sample Date	Type of Sample	Sampling Depth (ft)	UCS 7-day (psi)	UCS 14-day (psi)	UCS 28-day (psi)	Perm 7-day (cm/s)	Perm 14-day (cm/s)	Perm 28-day (cm/s)
1503336-C2	P	10/1/08	Daily Bulk Sample	32.0	Soft	28.3	104.4	Soft	Soft	3.97E-09
1503157-C2	P	10/1/08	Daily Bulk Sample	35.0	Soft	Soft	69.4	Soft	Soft	1.4E-07
1503396-C1	S	10/1/08	Daily Bulk Sample	27.0	Soft	101.1*	496.8	Soft	8.2E-08	1.56E-09
1503450-C2	S	10/2/08	Daily Bulk Sample	27.0	Soft	48.3	241.1	Soft	Soft	1.25E-07
1503536-C1	P	10/2/08	Daily Bulk Sample	35.0	Soft	47.8	286.2	Soft	2.8E-07	3.55E-09
1503819-C2	S	10/2/08	Daily Bulk Sample	30.0	Soft	Soft	173.4	Soft	Soft	7.82E-08
1504213-C1	P	10/3/08	Daily Bulk Sample	40.0	Soft	Soft	89.2	Soft	Soft	6.46E-08
1504330-C2	S	10/3/08	Daily Bulk Sample	40.0	Soft	Soft	91.8	Soft	Soft	1.15E-07
1504817-C1	P	10/5/08	Daily Bulk Sample	30.0	Soft	Soft	22.5	Soft	Soft	1.97E-07
1505216-C2	S	10/27/08	Daily Bulk Sample	30.0	Soft	Soft	61.4	Soft	Soft	2.22E-08
1505503-C1	P	10/28/08	Daily Bulk Sample	30.0	Soft	Soft	68.1	Soft	Soft	6.96E-08
1505914-C2	S	10/28/08	Daily Bulk Sample	40.0	Soft	Soft	11.4	Soft	Soft	2.82E-07
1506207-C1	P	10/30/08	Daily Bulk Sample	30.0	Soft	Soft	12.3	Soft	Soft	8.06E-08
1506501-C2	S	10/30/08	Daily Bulk Sample	30.0	Soft	Soft	18.8	Soft	Soft	6.56E-08
1506794-C1	P	11/01/08	Daily Bulk Sample	30.0	Soft	Soft	13.8	Soft	Soft	1.19E-07
1507087-C2	S	11/02/08	Daily Bulk Sample	30.0	Soft	Soft	68.1	Soft	Soft	4.29E-08
1507322-C1	P	11/04/08	Daily Bulk Sample	40.0	Soft	48.8	211.4	Soft	1.4E-07	2.72E-08
1507791-C2	S	11/05/08	Daily Bulk Sample	30.0	Soft	Soft	73.5	Soft	Soft	2.77E-08

Demonstration Section Station 1503+00 to 1508+00 - Post Placement Sample Summary

Sample ID	Panel Type	Sample Date	Type of Sample	Sampling Depth (ft)	UCS 28-day (see Note 1) (psi)	Perm 28-day (cm/s)
1504506-P1	S	10/24/08	Post-Placement	29	232.1 / 241.4	2.48E-06
1504506-P2	S	10/24/08	Post-Placement	49	139.5 / 190.4	9.94E-06
1504506-P3	S	10/24/08	Post-Placement	59	98.5 / 115.2	2.81E-06
1505973-P1	P	10/29/08	Post-Placement	29	10.5 / 13.5	2.89E-07
1505973-P2	P	10/29/08	Post-Placement	49	29.0 / 30.9	1.86E-07
1505973-P3	P	10/29/08	Post-Placement	59	7.9 / 7.9	1.51E-06
1507436-P1	S	11/04/08	Post-Placement	29	120.1 / 135.6	2.92E-06
1507436-P2	S	11/04/08	Post-Placement	39	96.1 / 83.9	3.33E-06
1507436-P3	S	11/04/08	Post-Placement	49	50.4 / 46.7	8.4E-08
1507436-P1A	S	11/06/08	Post-Placement	29	358.1 / 376.6	1.34E-07
1507436-P2A	S	11/06/08	Post-Placement	35	385.8 / 375.6	1.10E-07
1507436-P3A	S	11/06/08	Post-Placement	47	547.5 / 553.5	1.57E-07

Notes: * - UCS 16-day
1. Values shown represent test results from two separate cylinders obtained from the same sample batch and tested individually.

Abbreviations: UCS = Unconfined Compressive Strength
Perm = Permeability Test

Demonstration Section Station 1503+00 to 1508+00 - Verification Boring Sample Summary

Sample ID	Panel Type	Sample Date	Type of Sample	Sample Analyzed Yes/No	Sampling Depth (ft)	% Recovery (%)	UCS 28-day (psi)	Perm 28-day (cm/s)
1504505-V-01	S	11/18/08	Verification Core	Yes	17-18	83.6	642.7	Fluid Perm
1504505-V-02	S	11/18/08	Verification Core	Yes	28-33		548.5	
1504505-V-03	S	11/18/08	Verification Core	Yes	37.5-38.5		727.9	4.4E-10
1504505-V-04	S	11/18/08	Verification Core	Yes	47-48		677.5	
1505973-V-01	P	11/24/08	Verification Core	Yes	16.5-18	100.0	611.8	Fluid Perm
1505973-V-02	P	11/24/08	Verification Core	Yes	28.4-33		521.4	4.2E-07
1505973-V-03	P	11/24/08	Verification Core	Yes	43.5-45		683.4	
1505973-V-04	P	11/24/08	Verification Core	Yes	59.2-60		669.9	
1507439-V-01	S	12/01/08	Verification Core	Yes	19.5-20	89.7	605.9	Fluid Perm
1507439-V-02	S	12/01/08	Verification Core	Yes	30-31.1		725.6	
1507439-V-03	S	12/01/08	Verification Core	Yes	44.3-45		675.7	6.1E-09
1507439-V-04	S	12/01/08	Verification Core	Yes	49.4-50		628.3	

LEGEND

1503+00 Station Number

-30 Elevation (feet NAVD88)

Panel Type

- Primary Panel
- Secondary Panel
- Verification Borehole (not to scale horizontally)

1503039 Panel Number/Station

Sample Type

- Daily Bulk Sample
- Post-Placement Sample
- Verification Core Sample

Notes:
Mix Design #1 used between stations 1503+00 and 1508+00

NAVD88 - North American Vertical Datum of 1988

40 20 0 40 Feet

no vertical exaggeration 1:400

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

Herbert Hoover Dike
Rehabilitation Reach 1
Seepage Cutoff Wall, Task Order No. 2
Martin and Palm Beach Counties, Florida
Contract No. W912E9-07-D-0011

Profiles - Demonstration Section Station 1503+00 to 1508+00 QCS Test Locations and Results Summary

Rev. 0:	02 MAR 2009
Rev. 1:	05 MAR 2009
Drawn By: J.R.	Drawing No. AB-04
Ckd By: D.S.	Sheet 4 of 4

BAUER FOUNDATION

Bauer Foundation Corporation
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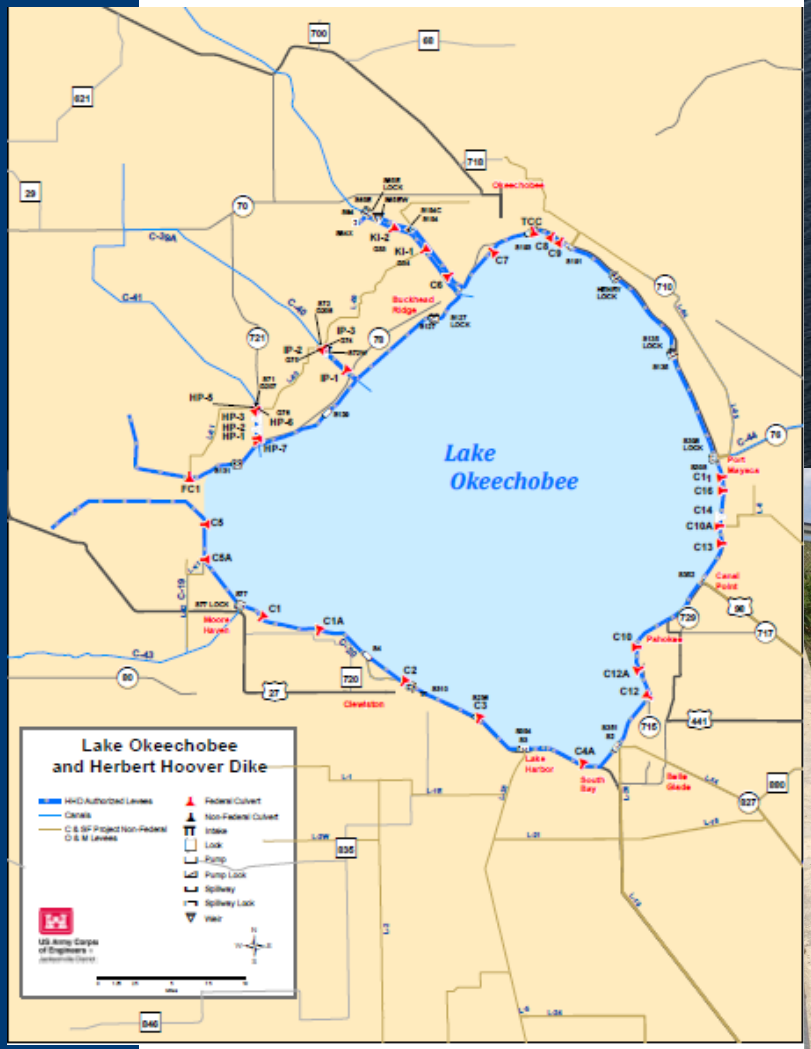
CULVERTS



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QUESTIONS

Thank you for your time and consideration today in discussing the Herbert Hoover Dike Rehabilitation Project.

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