35th Southwest Geotechnical Engineering Conference

Geotechnical Challenges – New Orleans USACE

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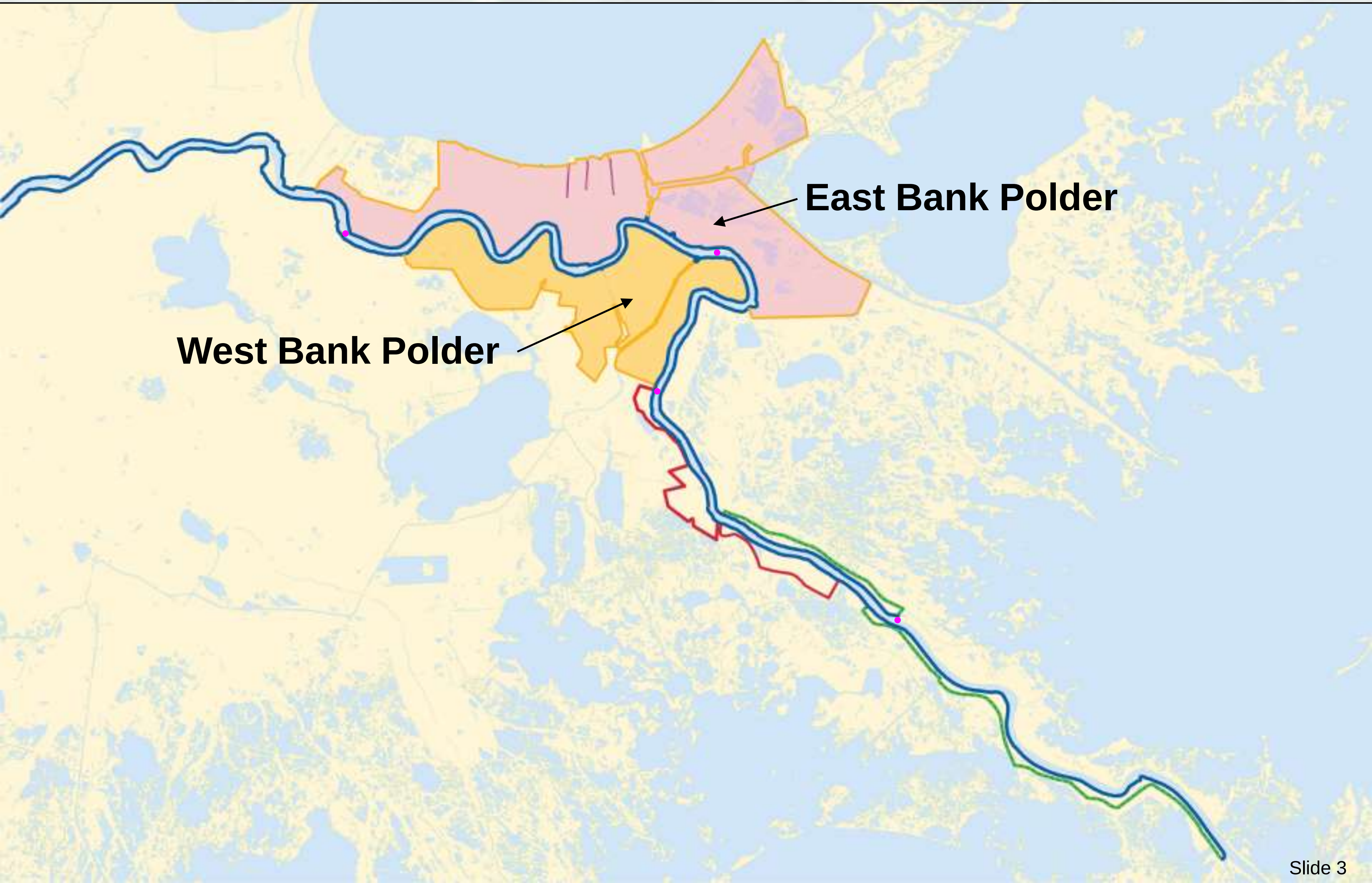
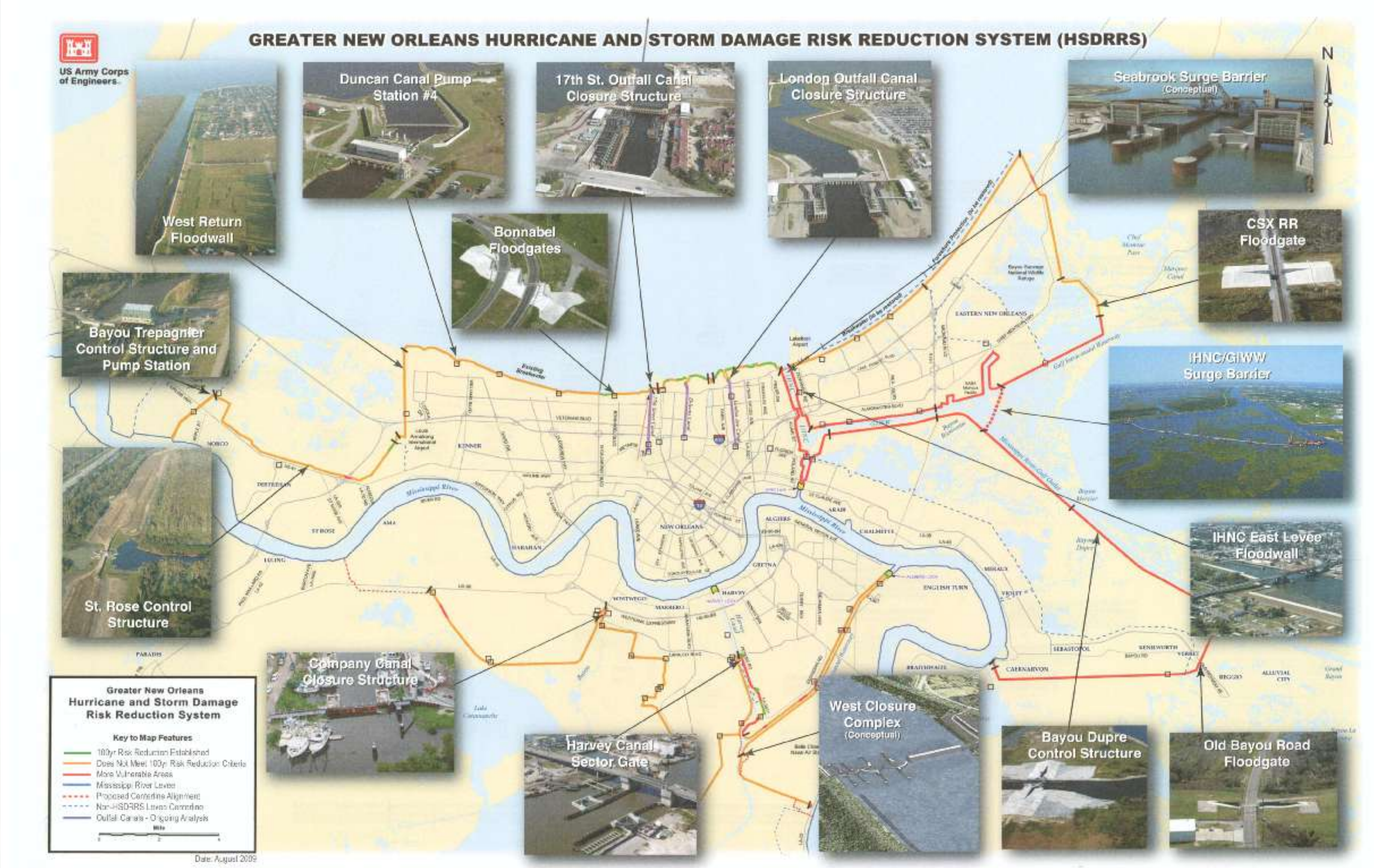
Geotechnical Branch
New Orleans District

28 April 2010

New Orleans District
New Orleans District Boundary
Gulf Intracoastal Waterway
Mississippi River and Tributaries Levee
Hurricane Protection Levee
Bank Protection
Deep Draft Waterway
Beneficial Use of Dredged Material
Acquisitions
Freshwater Diversion Structure
Saltwater Barrier
Lock
Control Structure
Pumping Station
BATON ROUGE
NEW ORLEANS
LAKE CHARLES
LAFAYETTE
MORGAN CITY
HOUMA
VENICE

New Orleans Area
Hurricane & Storm Damage Risk Reduction System





GREATER NEW ORLEANS HURRICANE AND STORM DAMAGE RISK REDUCTION SYSTEM (HSDRRS)
US Army Corps of Engineers
West Return Floodwall
Duncan Canal Pump Station #4
17th St. Outfall Canal Closure Structure
London Outfall Canal Closure Structure
Seabrook Surge Barrier (Conceptual)
Bonnabel Floodgates
CSX RR Floodgate
Bayou Trepagnier Control Structure and Pump Station
IHNC/GIWW Surge Barrier
St. Rose Control Structure
IHNC East Levee Floodwall
Company Canal Closure Structure
Harvey Canal Sector Gate
West Closure Complex (Conceptual)
Bayou Dupre Control Structure
Old Bayou Road Floodgate
Greater New Orleans Hurricane and Storm Damage Risk Reduction System
Key to Map Features
100yr Risk Reduction Established
Does Not Meet 100yr Risk Reduction Criteria
More Vulnerable Areas
Mississippi River Levee
Proposed Centerline Alignment
Non-HSDRRS Levee Centerline
Outfall Canals - Ongoing Analysis
Date: August 2009
N

HSDRRS Geotechnical Design Complexities

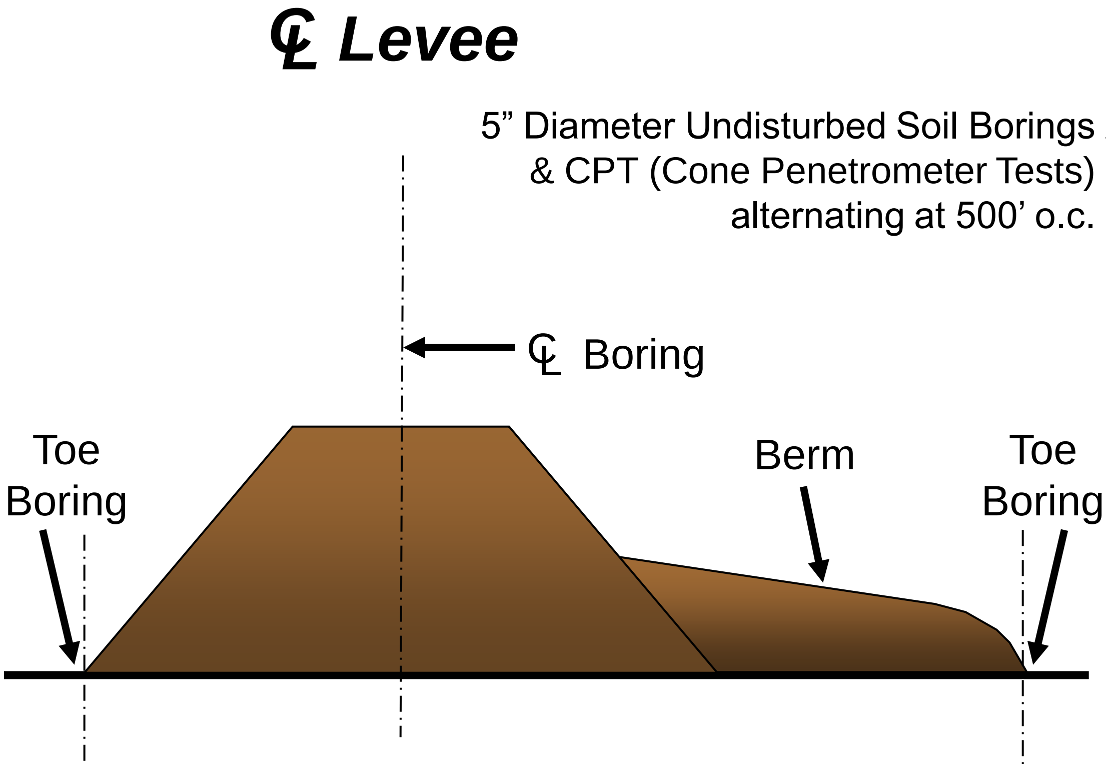
- Enormity of Soil Samples (min. 500 ft. o.c.) with expedited due dates for design
- Evaluation of unprecedented number of laboratory & field soil tests
  - Over 40,000 soil strength tests
  - Over 50,000 Atterberg Limit tests
  - Over 4,000 consolidation tests
  - Over 1,800 CPT soundings
  - Over 300 GeoProbes
- Multitude of slope stability runs, with a multitude of soil stratifications
- Modifications to the two Spencer Slope Stability Software Programs – SlopeW & UTEXAS4 – on a National level due to soft soils & geotextiles in SE LA
- Assessment/Validity of results
  - Soil Strengths
  - CPT Data
  - Critical Failure Planes
- Results impact both Levee Footprint & Cost

HSDRRS Unparalleled Design Support

Design Support From:

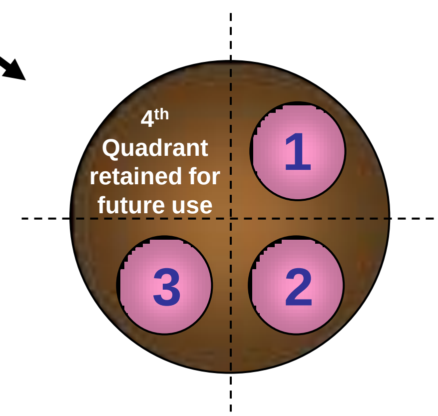
- Five MVD Districts: St. Paul, Rock Island, St. Louis, Memphis & Vicksburg
  - Rock Island District & Above Districts – Major Contributors to West Closure Complex & West Bank Projects
  - Districts assumed "ownership" of work in lieu of brokering
- Embedded Contractor Workforce in Civil, Geotechnical, Project & Structural Design, including Dutch Contingent in Hydraulic Design
- Embedded Contractor Workforce in GIS & Surveying Support
- Large Capacity in A/E Contract Services
  - Surveying & Mapping (6 contracts, $35M)
  - Hydraulic Design (4 contracts, $9M)
  - General Design (24 contracts, $98M)
  - $100M Geotechnical Exploration & Testing, with state of the art soils lab
    - Joint Venture consisting of two national and two local firms

Typical Levee Section
& Geotechnical Field Investigation



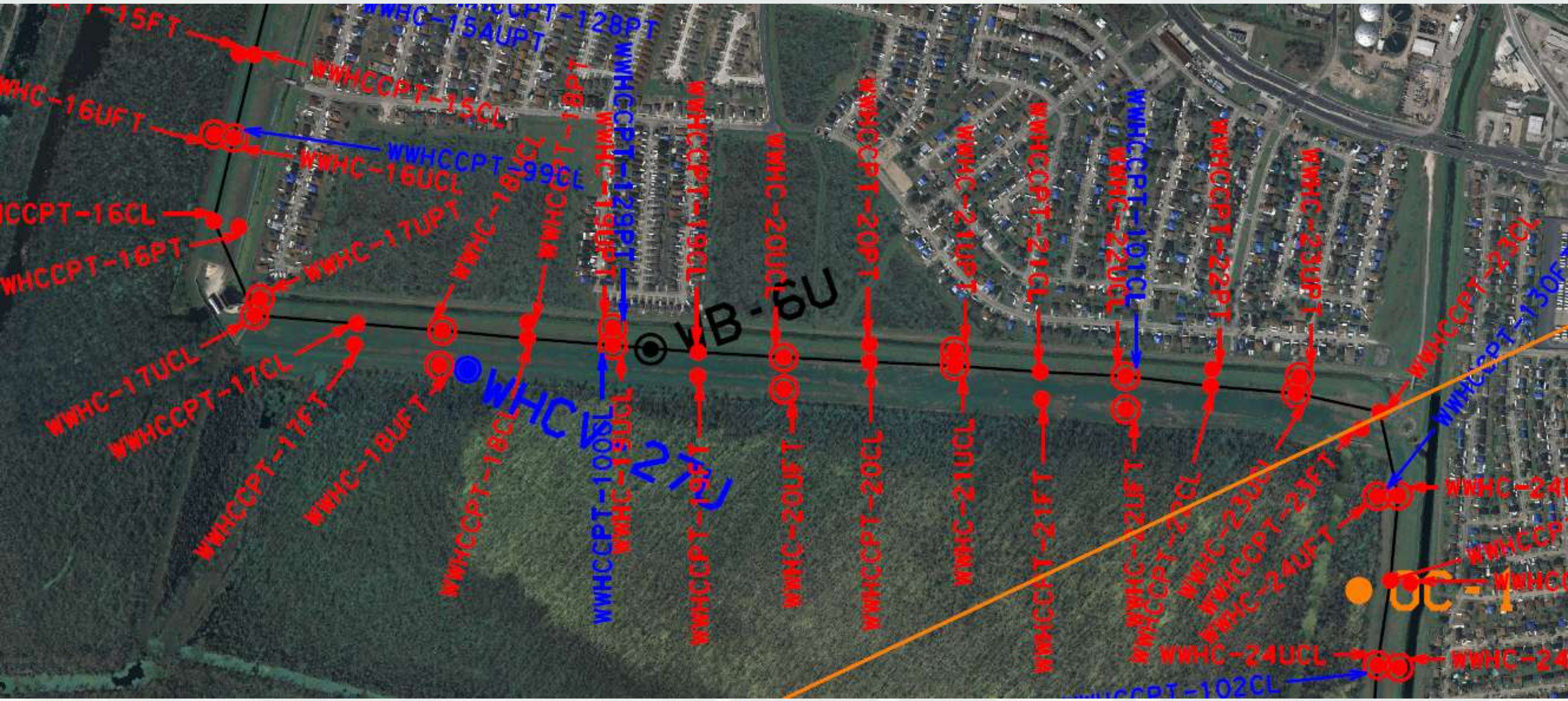
Typical Levee Section

5” Diameter Soil Boring



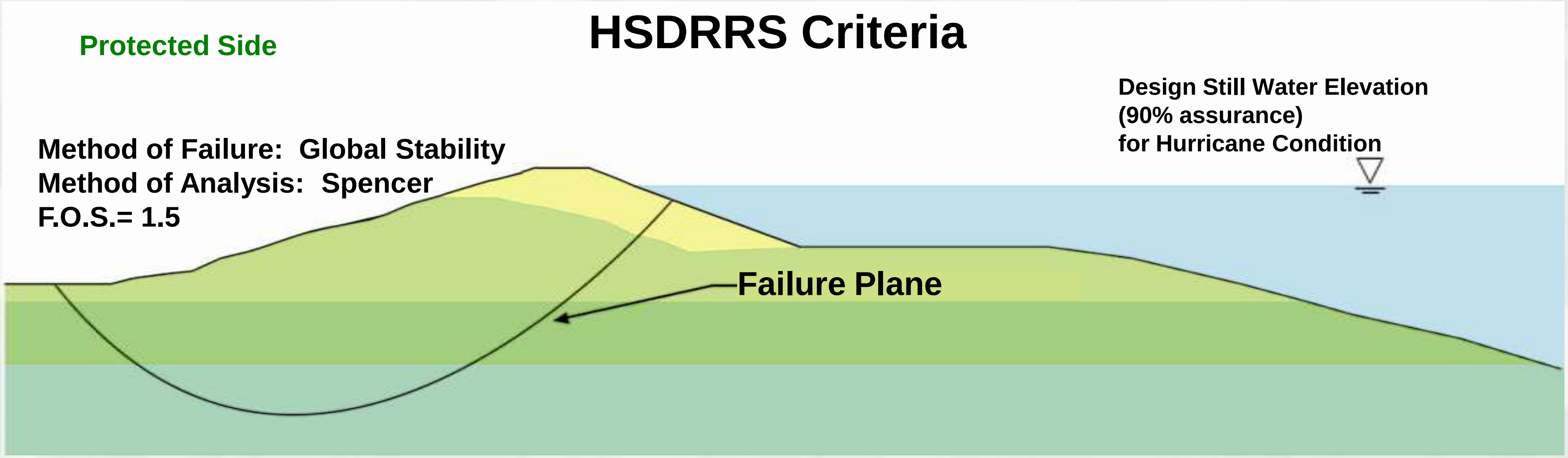
Circular Soil Sample cut into 4 Quadrants with 3 samples tested (trimmed circular)

Subsurface Explorations 500’ OC

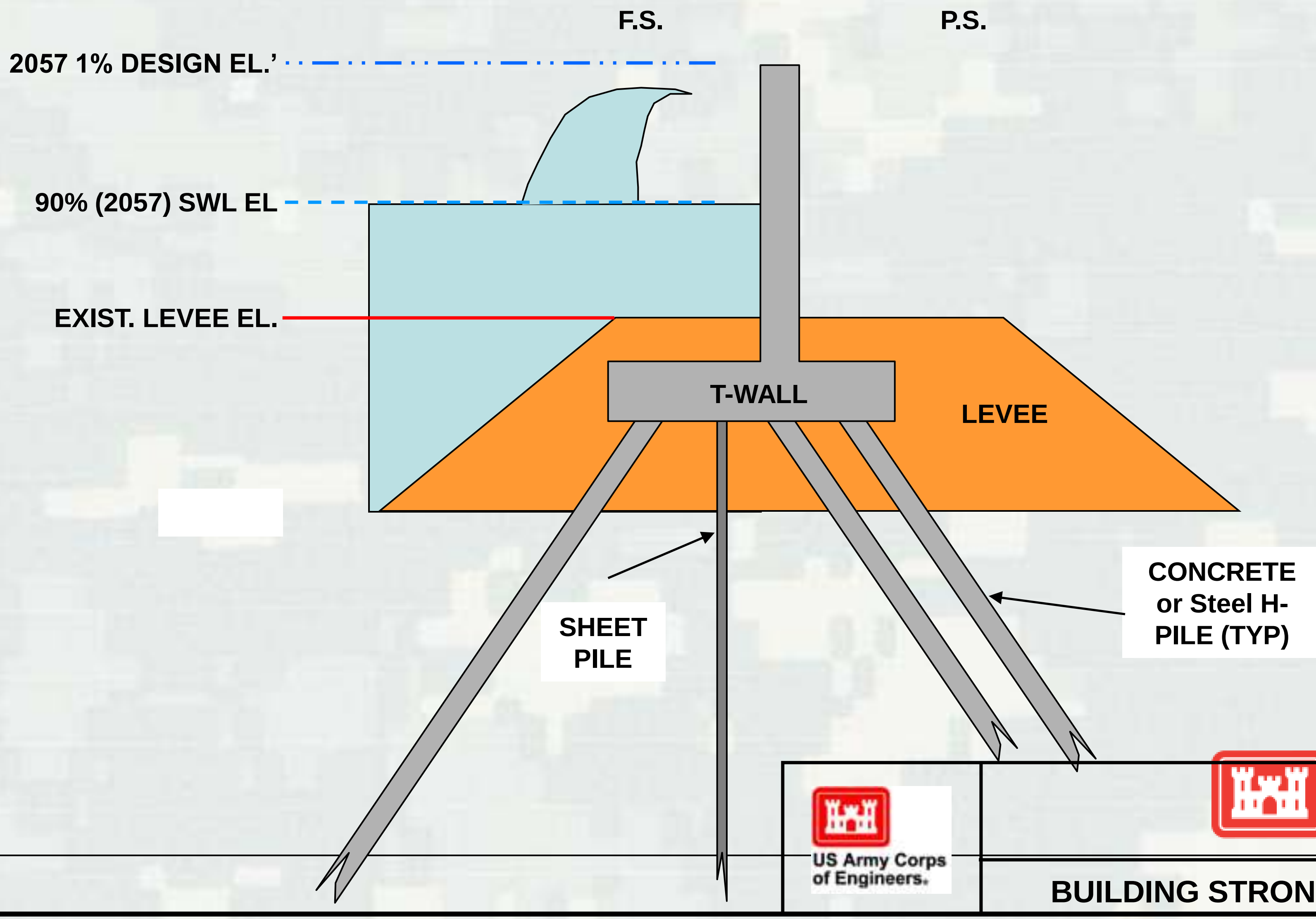



Consolidation
Specimen
Preparation
DO
NOT
DISTURB

Current Geotechnical Levee Criteria



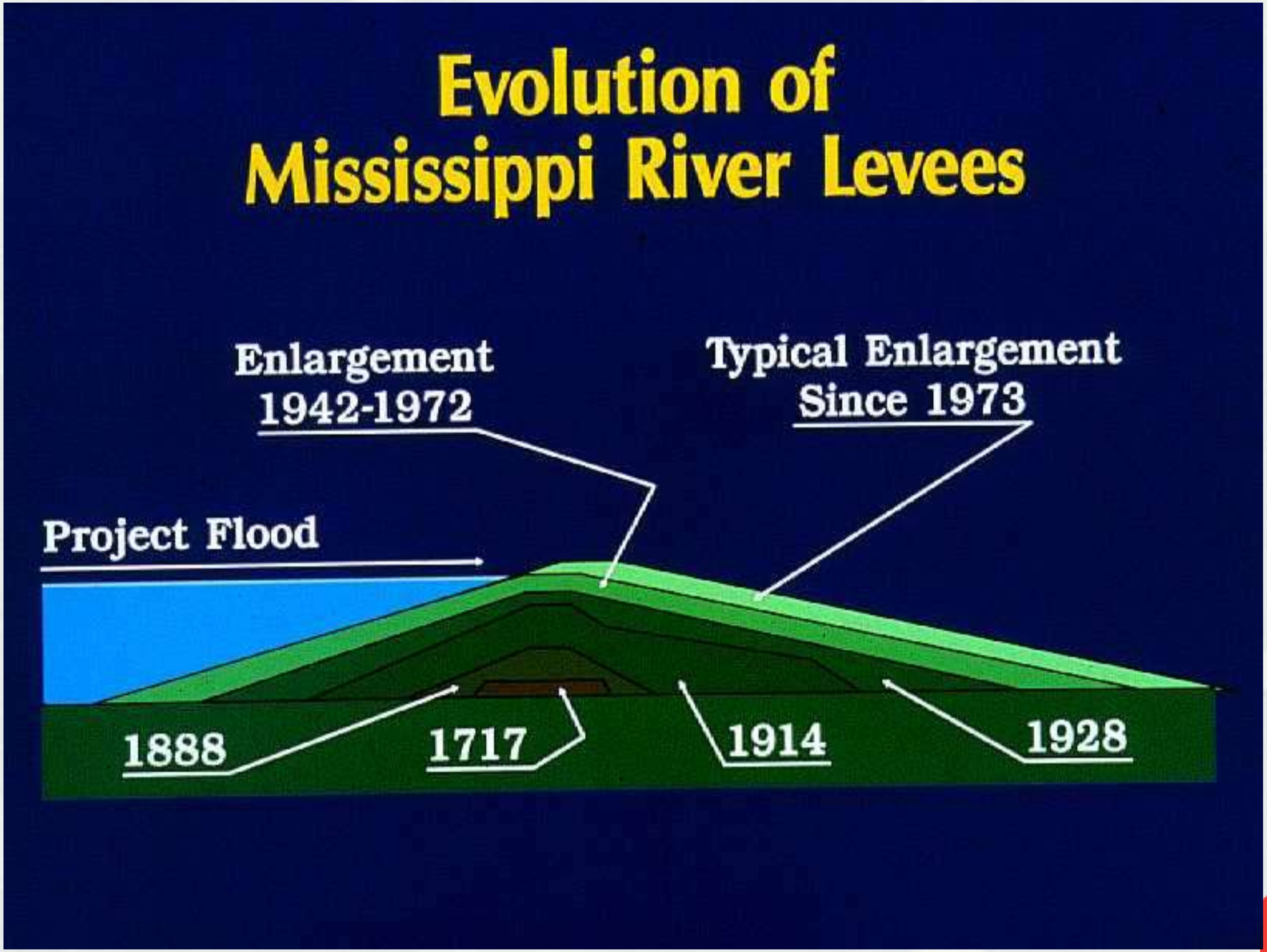
	Required Minimum Factor of Safety	
Analysis Condition	Spencer Method	MOP
End of Construction	1.3	1.3
Design Hurricane (SWL)	**1.5**	1.3
Water at Project Grade (Levees)	**1.4**	1.2
Water at Construction Grade (Levees)	1.2	N/A
Extreme Hurricane (Water @ Top of I-Walls)	1.4	1.3
Extreme Hurricane (Water @ Top of T-Walls)	1.4	1.2
Low Water (Hurricane Condition)	1.3	1.3
Low Water (Non-Hurricane Condition) S-Case	1.4	1.3

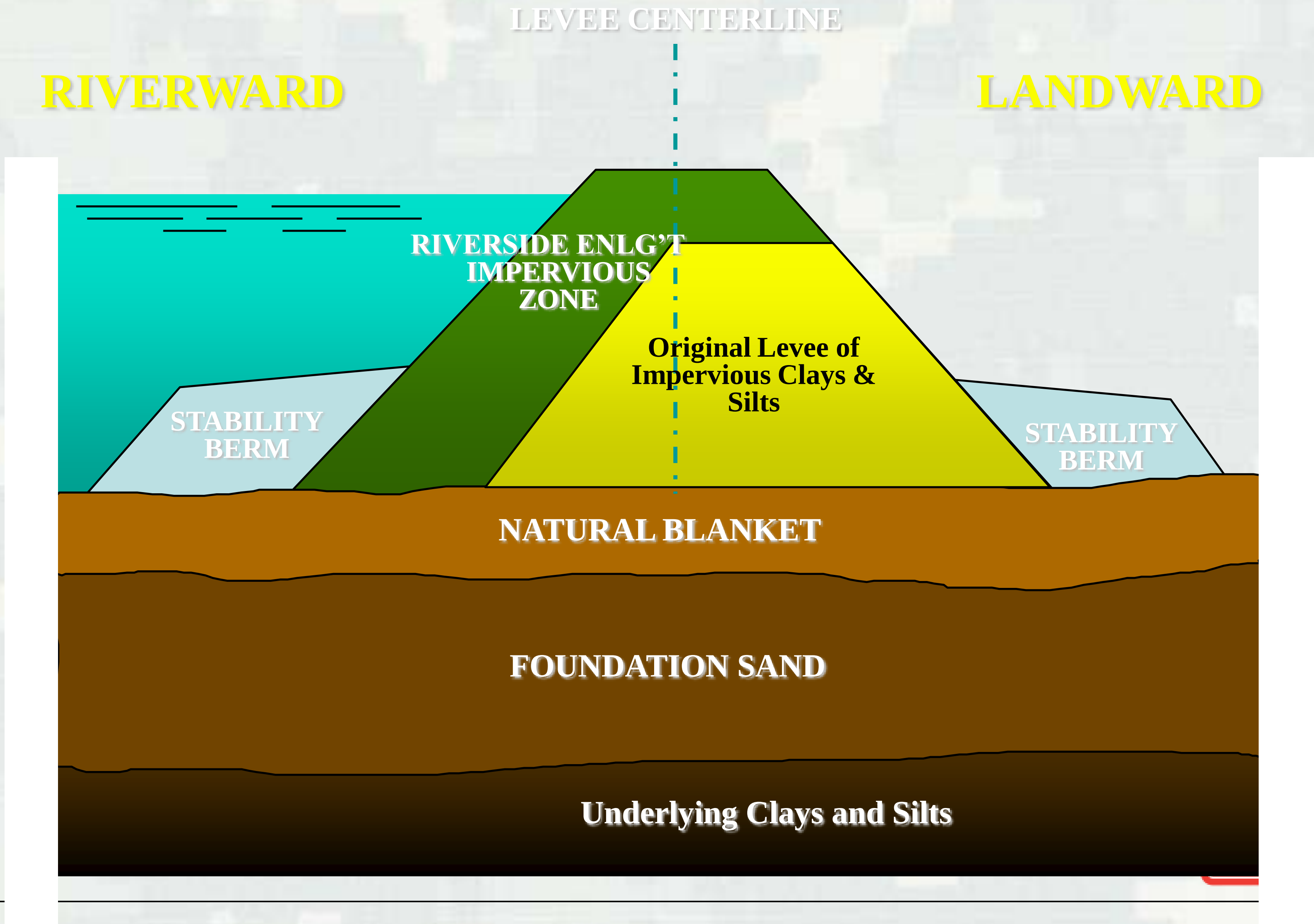

F.S.
P.S.
2057 1% DESIGN EL.'
90% (2057) SWL EL
EXIST. LEVEE EL.
T-WALL
LEVEE
SHEET PILE
CONCRETE or Steel H-PILE (TYP)

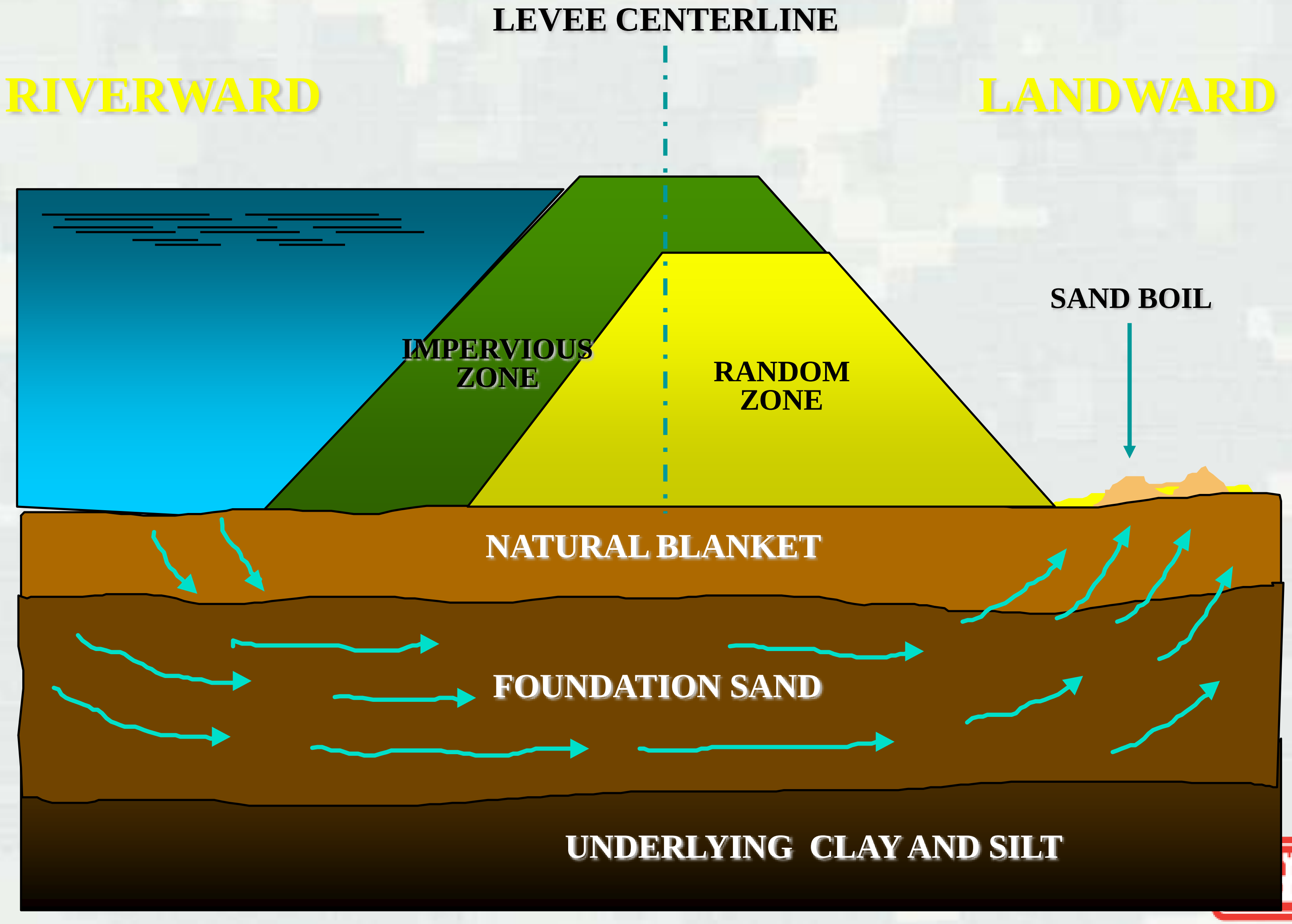
Seepage Concerns on Mississippi River Levees

HIGH WATER EFFECTS ON FLOOD CONTROL PROJECTS

- Overtopping
- Sand Boils
- Seepage
- Sloughing
- Wave Wash
- Erosion


Evolution of
Mississippi River Levees
Enlargement
1942-1972
Typical Enlargement
Since 1973
Project Flood
1888
1717
1914
1928


LEVEE CENTERLINE
RIVERWARD
LANDWARD
RIVERSIDE ENLG'T
IMPERVIOUS
ZONE
Original Levee of
Impervious Clays &
Silts
STABILITY
BERM
STABILITY
BERM
NATURAL BLANKET
FOUNDATION SAND
Underlying Clays and Silts


LEVEE CENTERLINE
RIVERWARD
LANDWARD
SAND BOIL
IMPERVIOUS ZONE
RANDOM ZONE
NATURAL BLANKET
FOUNDATION SAND
UNDERLYING CLAY AND SILT

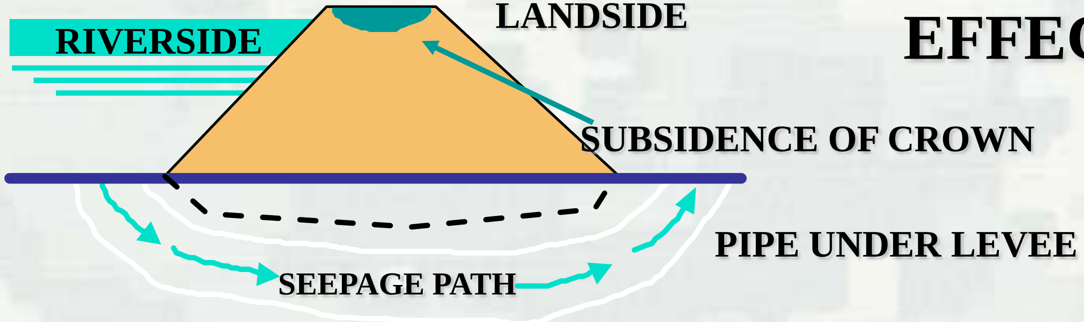
EFFECTS OF SANDBOILS

- Development of pipe under the levee

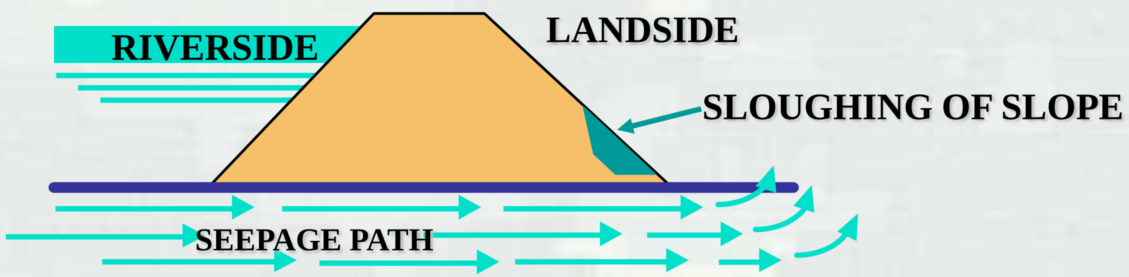
The pipe develops from the landside toward the flood side. Material is ejected in a cone shape around a spring head. The levee crest may be noticed to sag.

- Sloughing of landside levee slope near the toe
- Development of a landside shear or slide

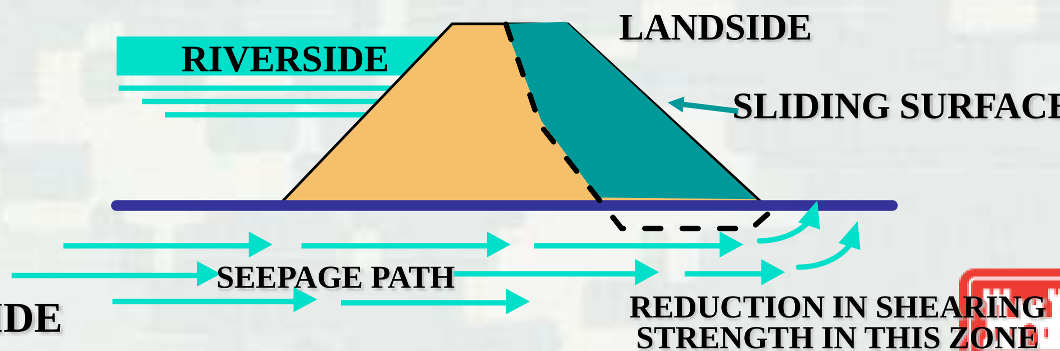
EFFECTS OF SAND BOILS ON LEVEE



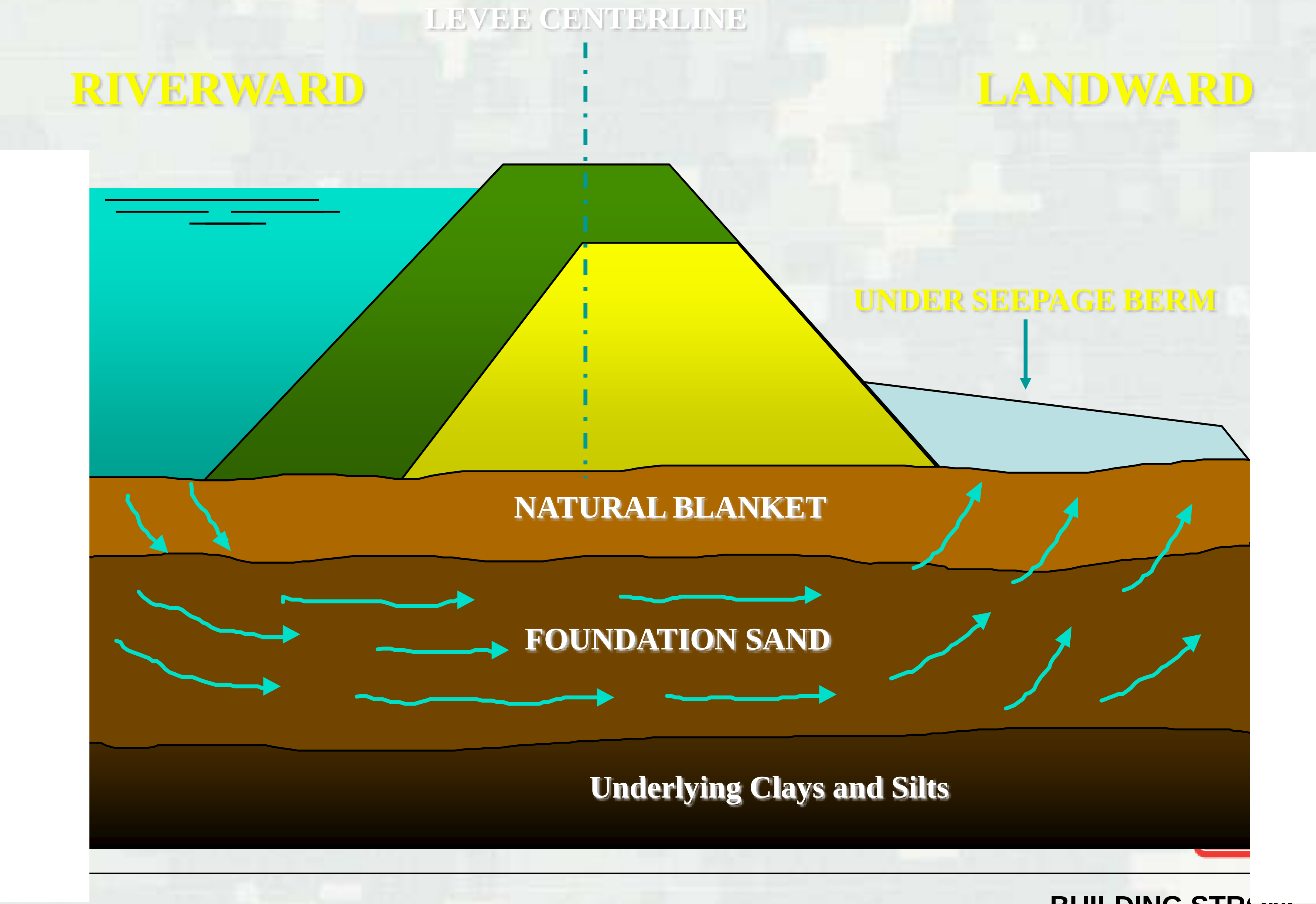
DEVELOPMEMENT OF PIPE UNDER LEVEE
FIG. 1



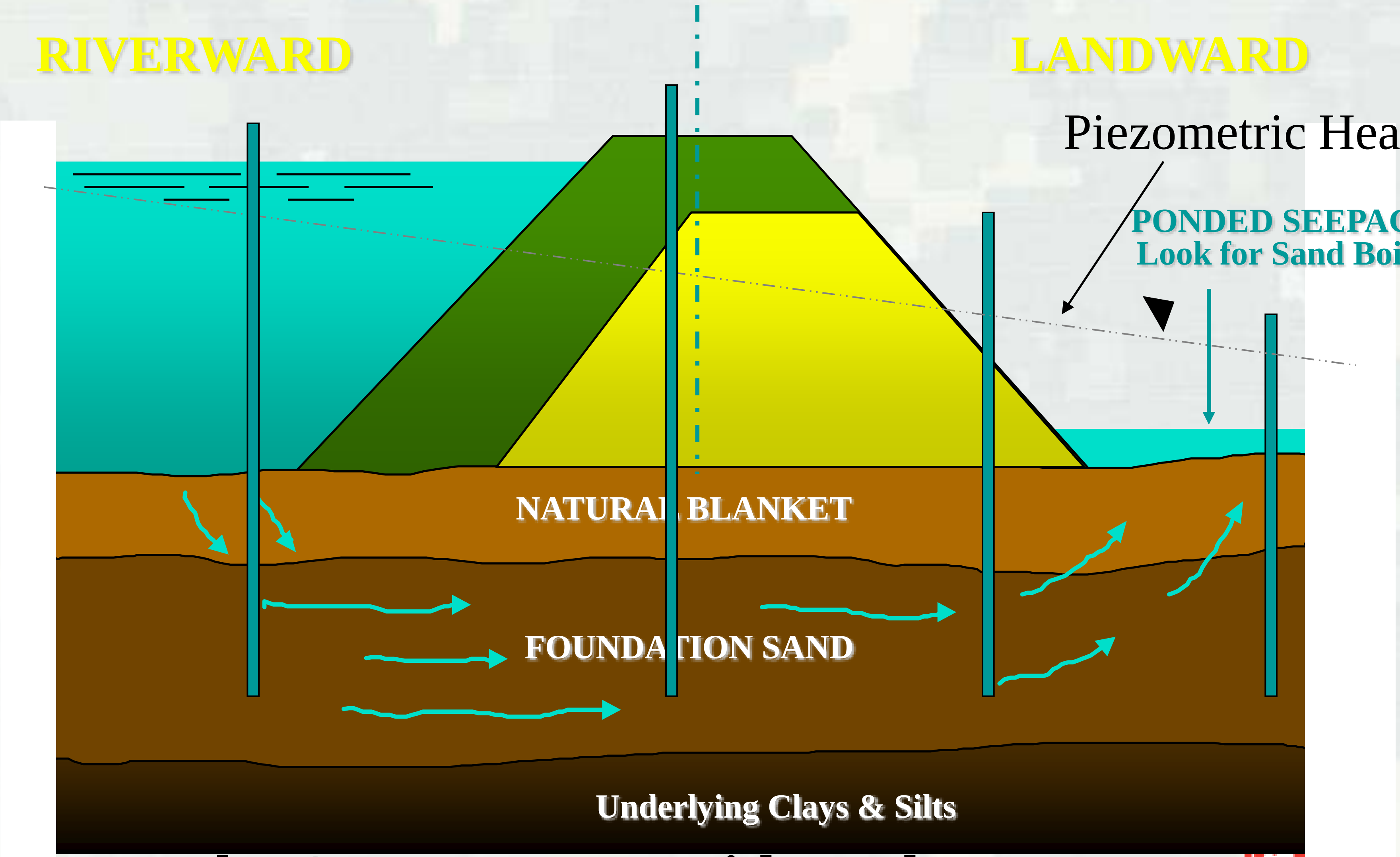
SLOUGHING OF LANDSLIDE SLOPE DUE TO
RAVELLING AND UNDERCUTTING OF TOE
FIG. 2



DEVELOPMENT OF SHEAR SLIDE
FIG. 3

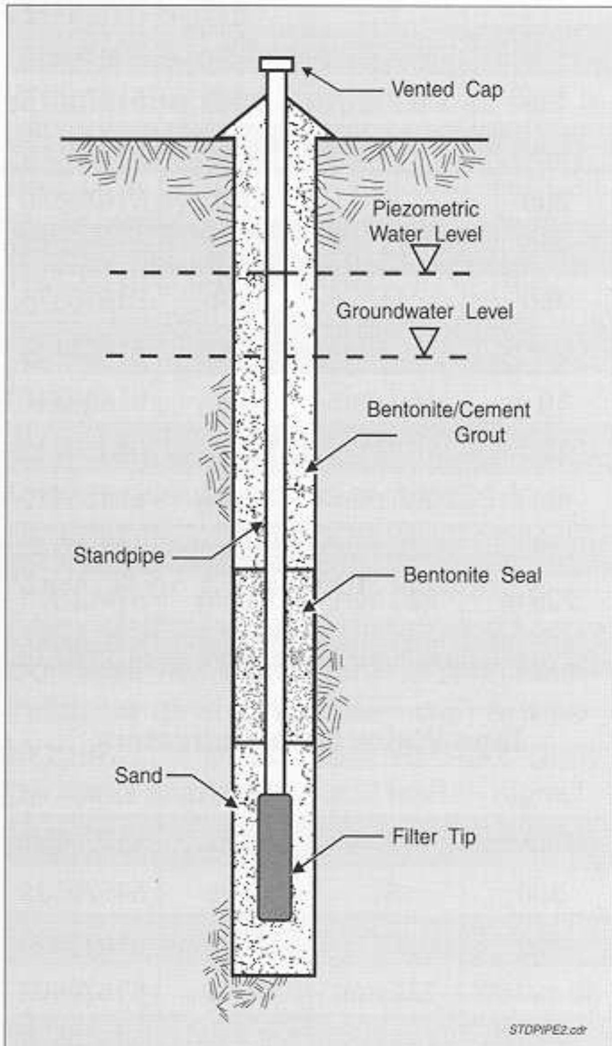

LEVEE CENTERLINE
RIVERWARD
LANDWARD
UNDER SEEPAGE BERM
NATURAL BLANKET
FOUNDATION SAND
Underlying Clays and Silts

LEVEE CENTERLINE

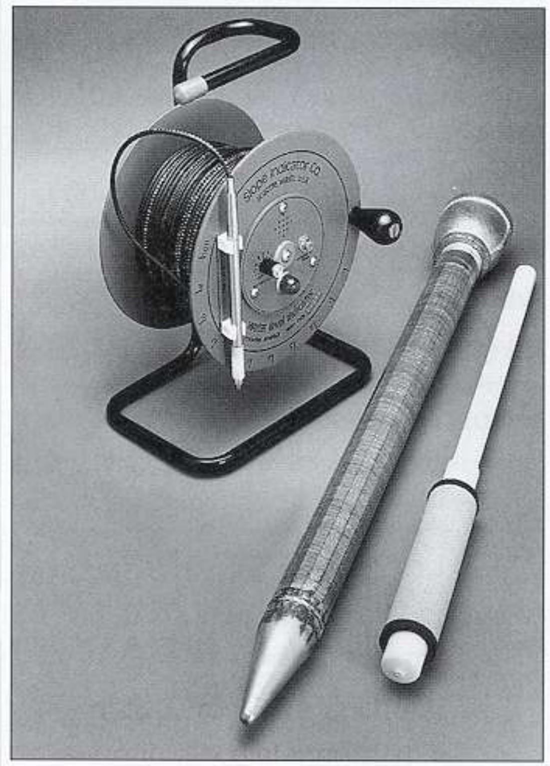


Under Seepage Event with Leakage at Levee Toe

Open System Piezometers

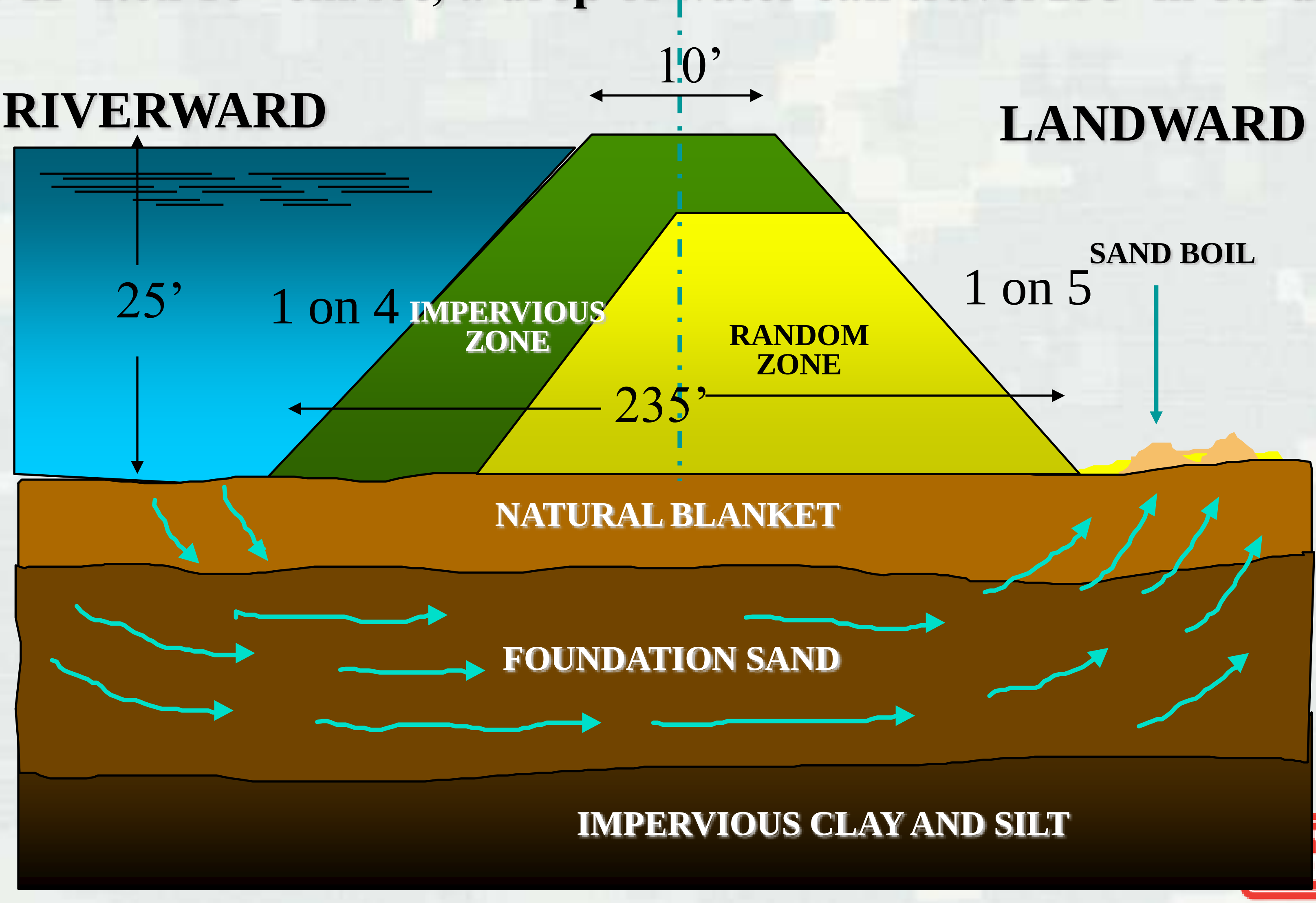


Standpipe (Casagrande) Piezometer



Water Level Indicator and Filter Tips.

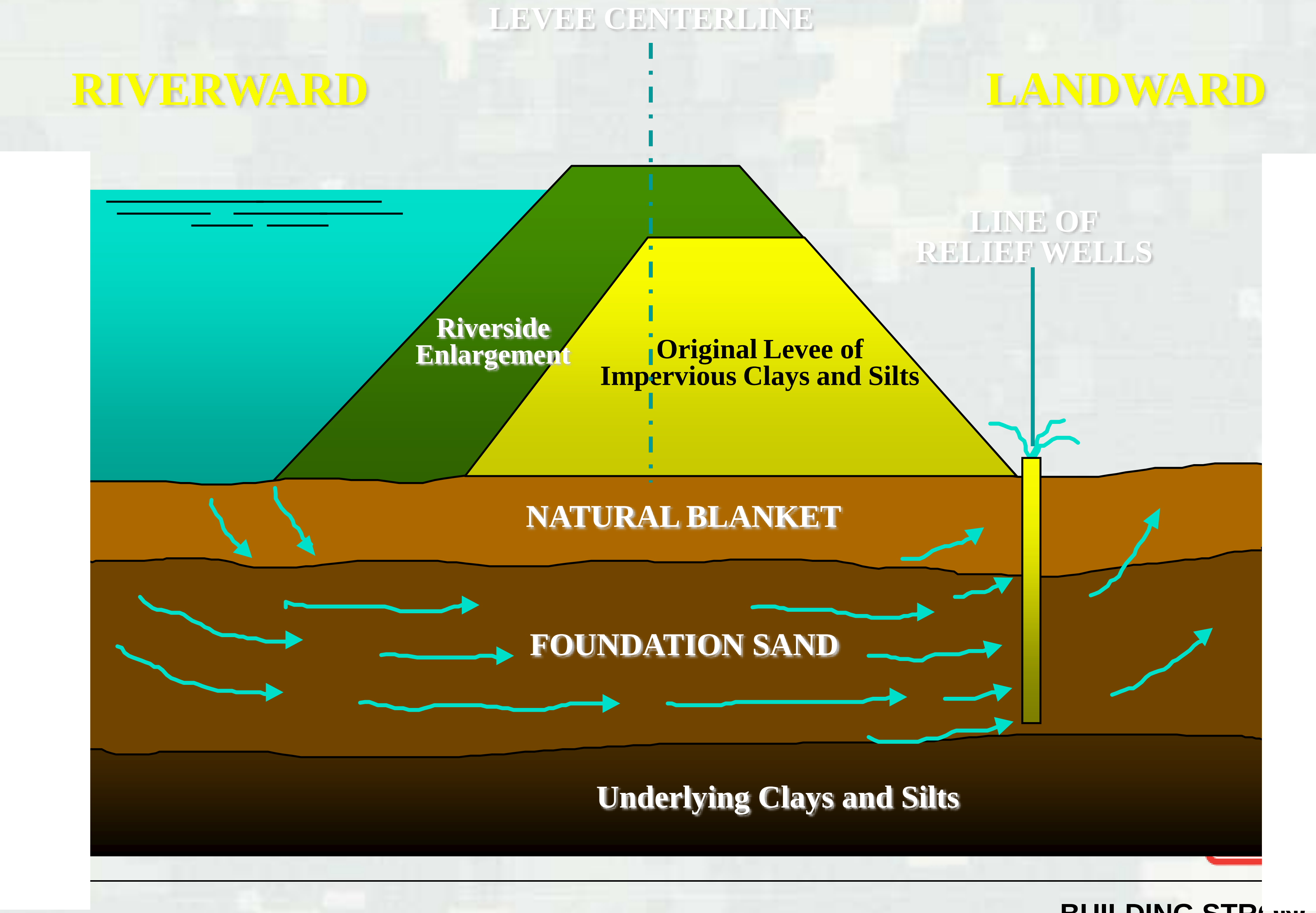
For K=1.0x 10^{-2} cm/sec, a drop of water can travel 235’ in 8.5 days



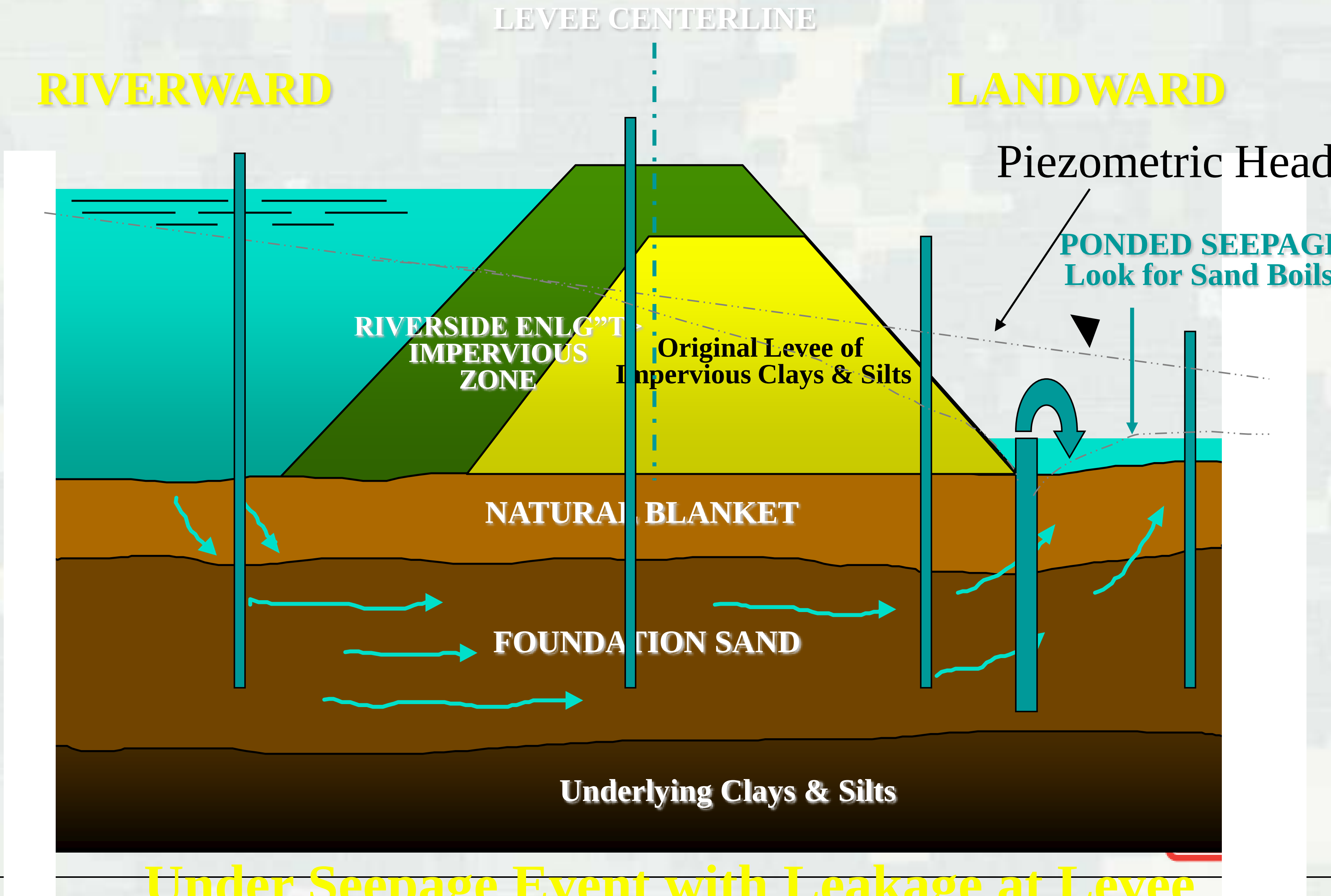

31 MAY 2009

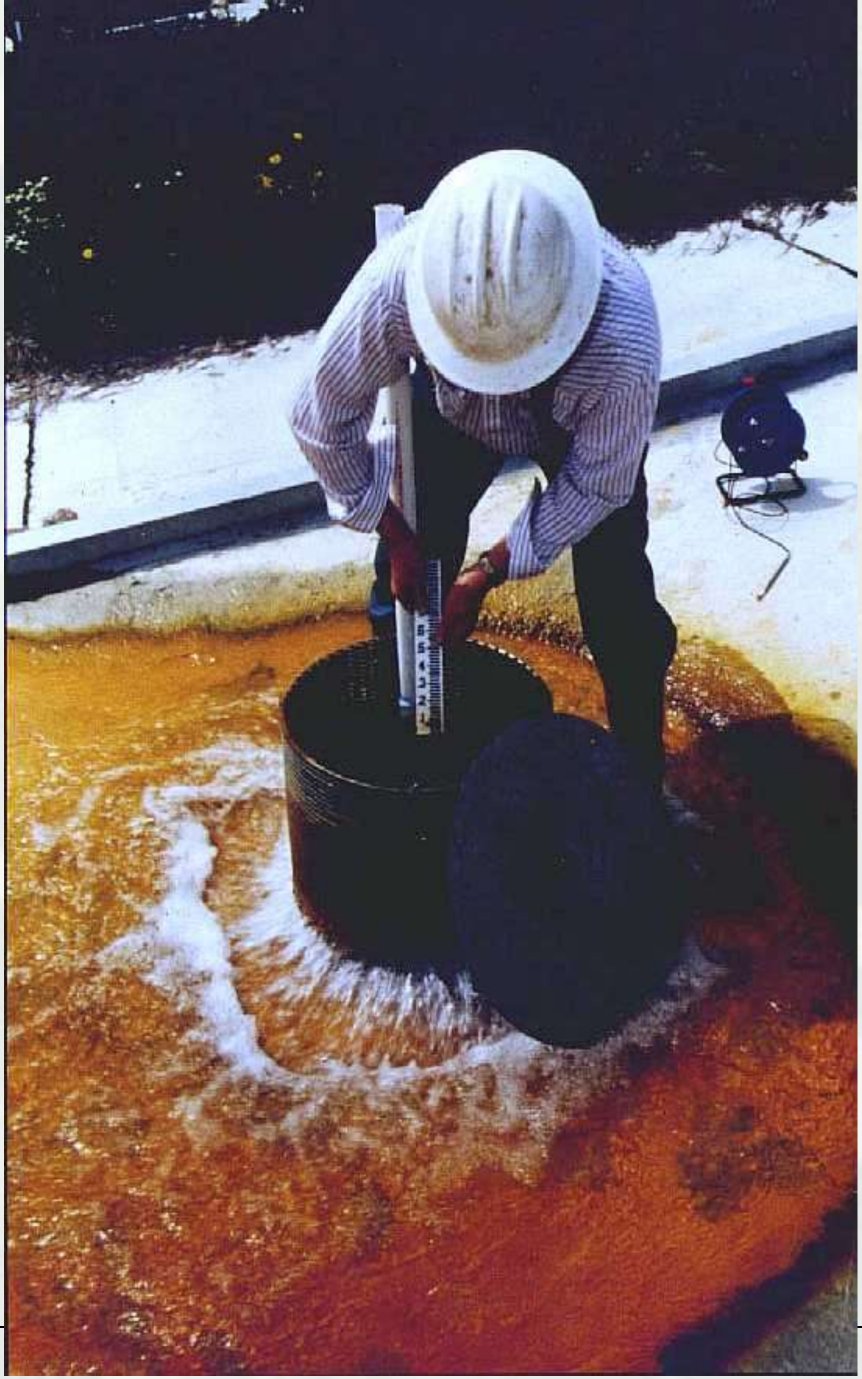

31 MAY 2009

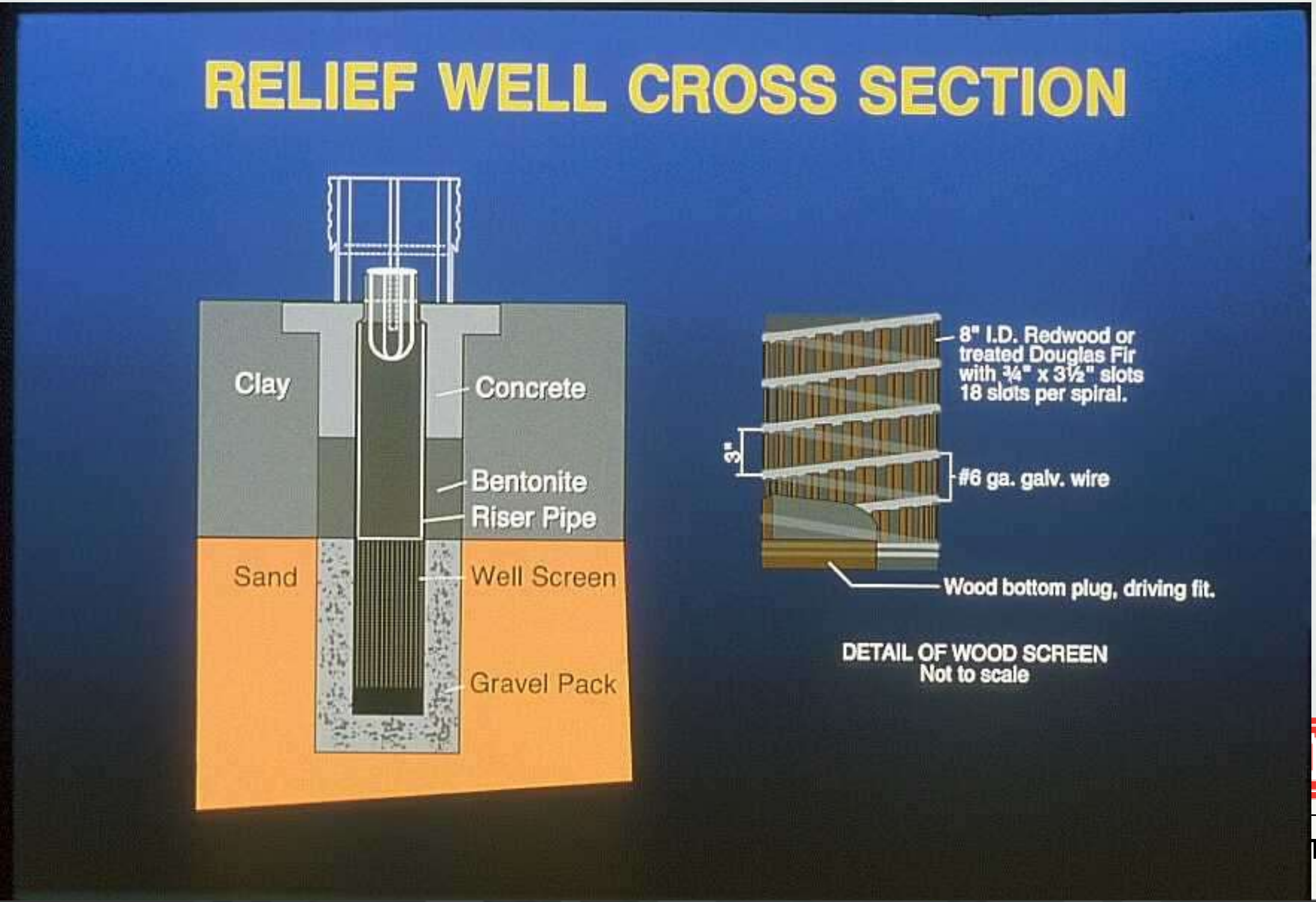

KIDNEY BEANS


LEVEE CENTERLINE
RIVERWARD
LANDWARD
LINE OF
RELIEF WELLS
Riverside
Enlargement
Original Levee of
Impervious Clays and Silts
NATURAL BLANKET
FOUNDATION SAND
Underlying Clays and Silts

Under Seepage Event with Leakage at Levee Toe



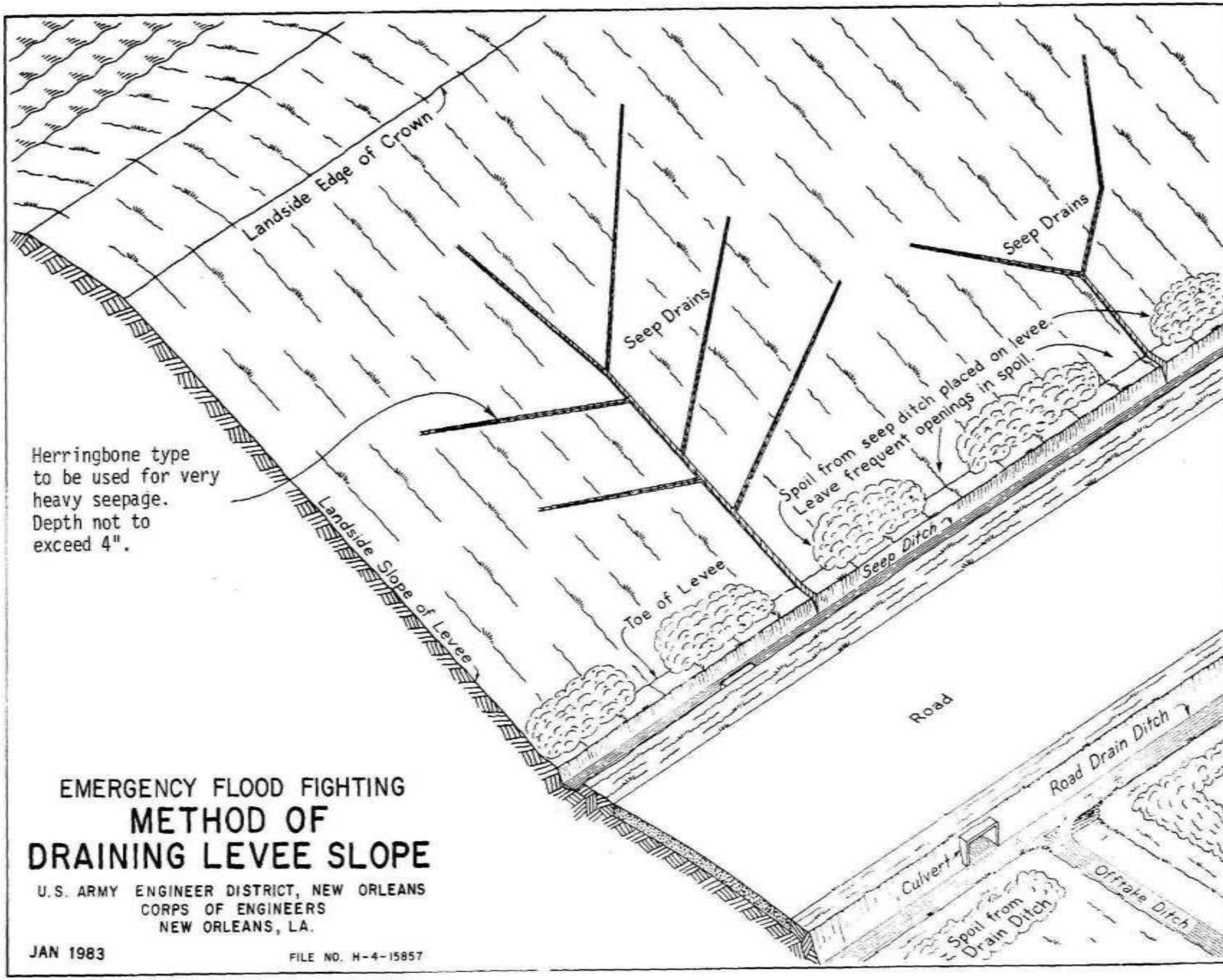



RELIEF WELL CROSS SECTION
Clay
Concrete
Bentonite
Riser Pipe
Sand
Well Screen
Gravel Pack
8" I.D. Redwood or treated Douglas Fir with ¾" x 3½" slots 18 slots per spiral.
3"
#6 ga. galv. wire
Wood bottom plug, driving fit.
DETAIL OF WOOD SCREEN
Not to scale

Open barrel used to control sandboils


31 MAY 2009


OUT
OUT



EMERGENCY FLOOD FIGHTING
METHOD OF DRAINING LEVEE SLOPE
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS
NEW ORLEANS, LA.

JAN 1983

FILE NO. H-4-15857

PLATE I

Deep Soil Mixing

Deep Soil Mixing

- Inject lime, cement, slag, fly ash, etc. into soil
- Mix thoroughly
- Creates a pozzolanic reaction in the soil/cement mass

Deep Mixing Design Parameters

- **WET MIXING**
- Water/binder ratio
- Binder load
- Number of shafts to suit application
- Spoil disposal

WET METHOD

- Excellent overlap
- Adaptable to multiple augers
- High strength
- Spoil disposal

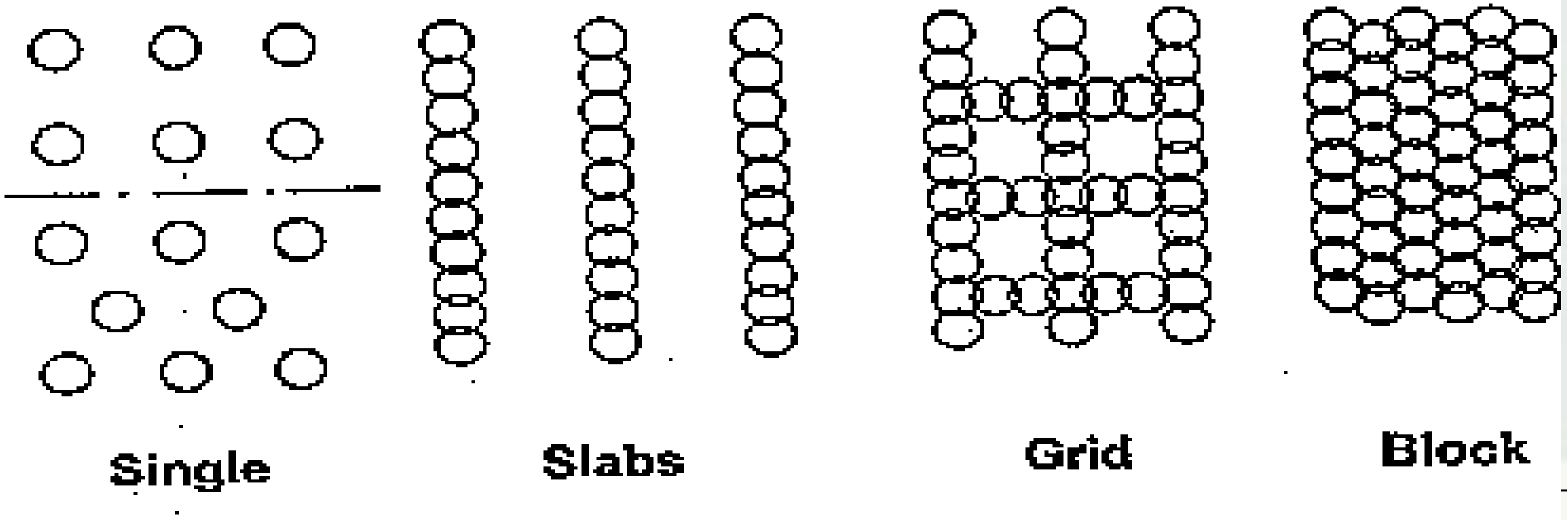
- **DRY MIXING**
- Binder load
- Mixing energy
- Rate of penetration
- Soil moisture

DRY METHOD

- No spoil
- No water needed
- Medium to high strength

Design for the purpose

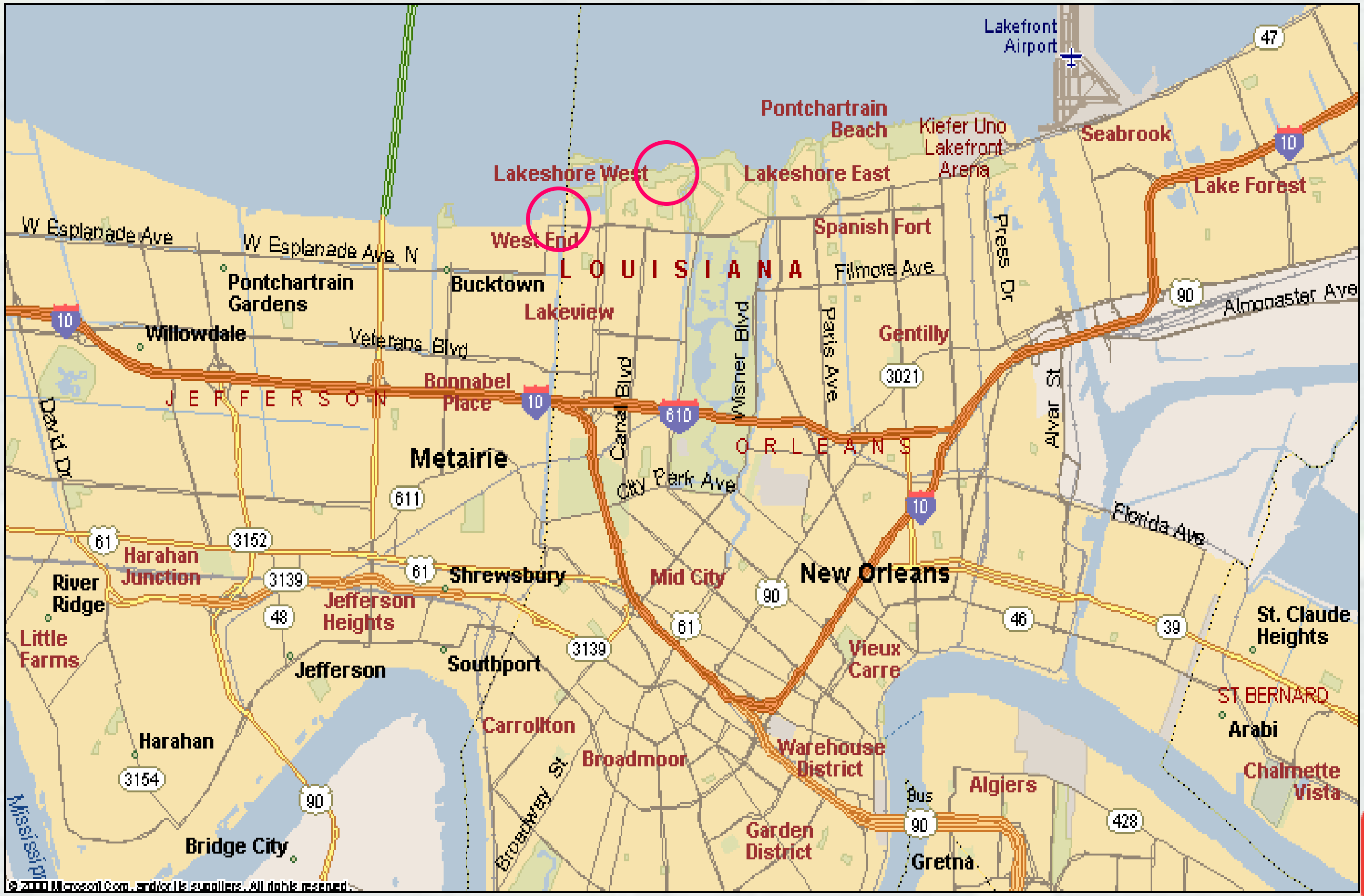
- Stability and support – strength, array, length, uniformity
- Seepage cutoff – continuity, overlap, length, permeability
- Seismic retrofit – All of the above



Three DM Applications

- Resist deflection of major structures
- Buttress existing floodwalls
- Reinforce new embankments

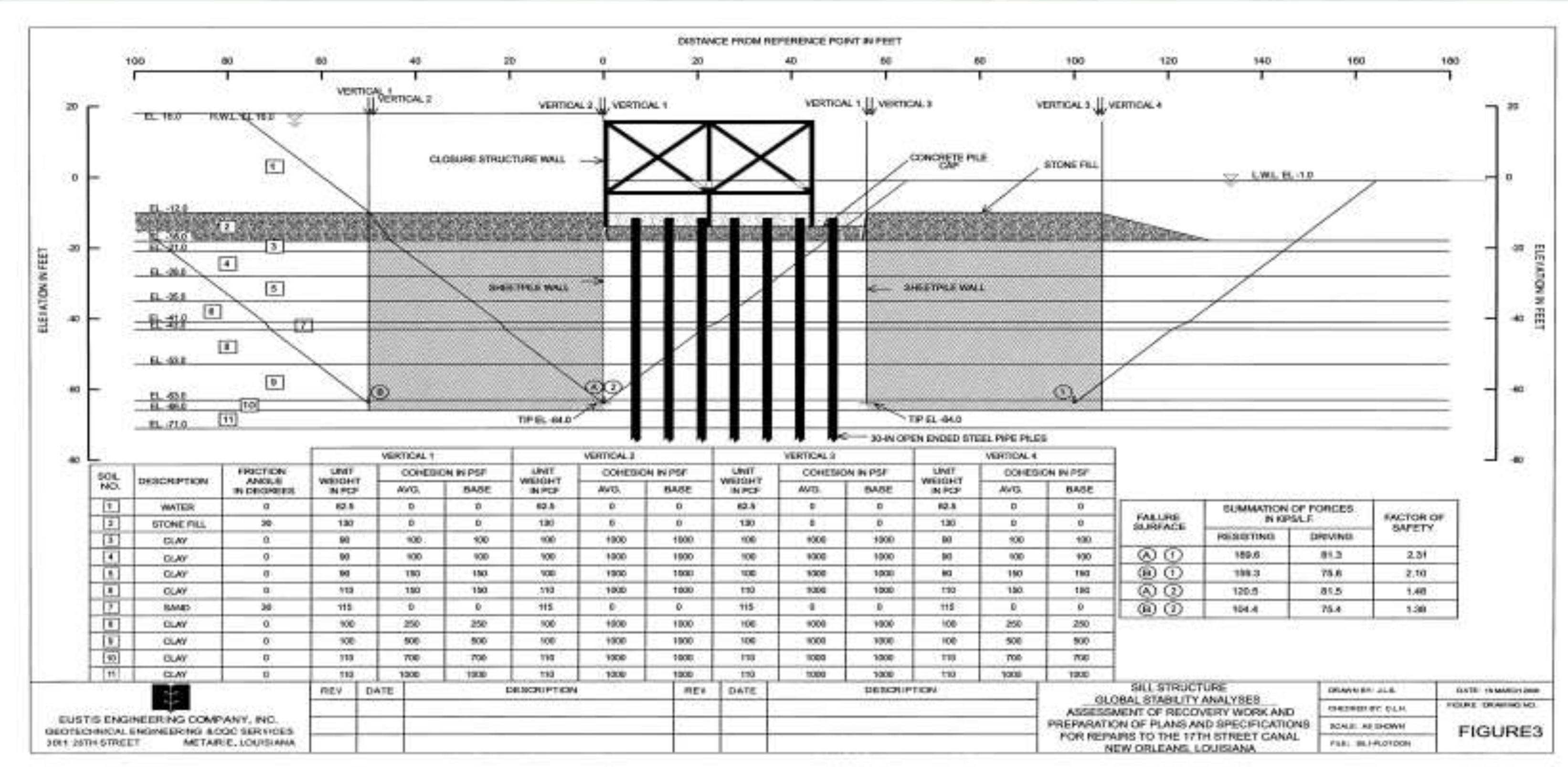
Major Structures - 17th Street & Orleans Avenue Canals Interim Closure Structures (2006)



17^{th} Street Canal
Interim Closure Structure (2006)

17th Street Canal
Interim Closure Structure (2006)

17th Street Canal
Interim Closure Structure (2006)



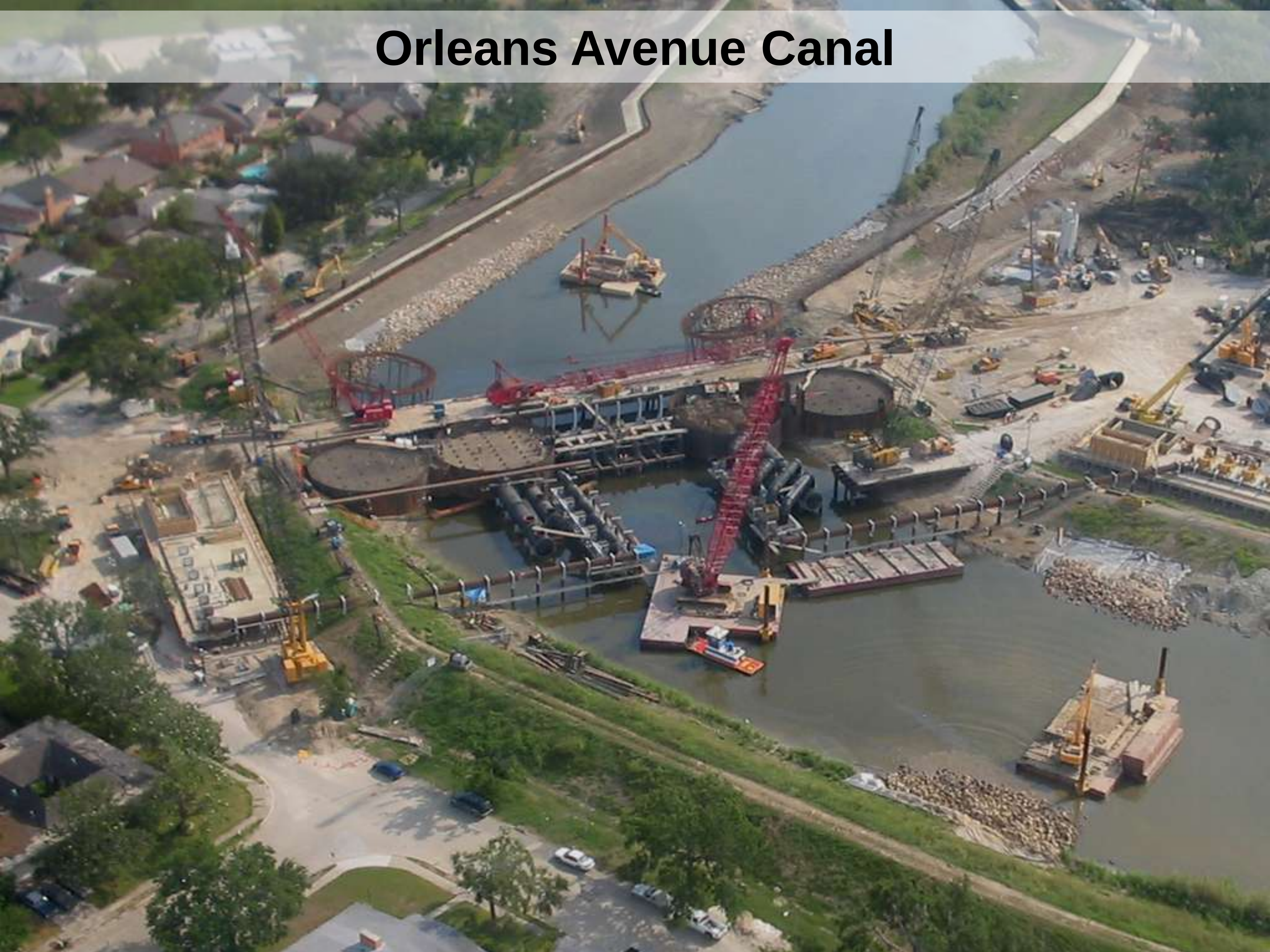
SOIL NO.	DESCRIPTION	FRICTION ANGLE IN DEGREES	VERTICAL 1			VERTICAL 2			VERTICAL 3			VERTICAL 4		
			UNIT WEIGHT IN PCF	COHESION IN PSF AVG.	COHESION IN PSF BASE	UNIT WEIGHT IN PCF	COHESION IN PSF AVG.	COHESION IN PSF BASE	UNIT WEIGHT IN PCF	COHESION IN PSF AVG.	COHESION IN PSF BASE	UNIT WEIGHT IN PCF	COHESION IN PSF AVG.	COHESION IN PSF BASE
1	WATER	0	62.5	0	0	62.5	0	0	62.5	0	0	62.5	0	0
2	STONE FILL	30	130	0	0	130	0	0	130	0	0	130	0	0
3	CLAY	0	90	100	100	100	1000	1000	100	1000	1000	90	100	100
4	CLAY	0	90	100	100	100	1000	1000	100	1000	1000	90	100	100
5	CLAY	0	90	150	150	100	1000	1000	100	1000	1000	90	150	150
6	CLAY	0	110	150	150	110	1000	1000	110	1000	1000	110	150	150
7	SAND	30	115	0	0	115	0	0	115	0	0	115	0	0
8	CLAY	0	100	250	250	100	1000	1000	100	1000	1000	100	250	250
9	CLAY	0	100	500	500	100	1000	1000	100	1000	1000	100	500	500
10	CLAY	0	110	700	700	110	1000	1000	110	1000	1000	110	700	700
11	CLAY	0	110	1000	1000	110	1000	1000	110	1000	1000	110	1000	1000

FAILURE SURFACE	SUMMATION OF FORCES IN KIPS/L.F. RESISTING	SUMMATION OF FORCES IN KIPS/L.F. DRIVING	FACTOR OF SAFETY
(A) (1)	189.6	81.3	2.31
(B) (1)	159.3	75.6	2.10
(A) (2)	120.5	81.5	1.48
(B) (2)	104.4	75.4	1.38

Orleans Avenue Canal
Interim Closure Structure (2006)

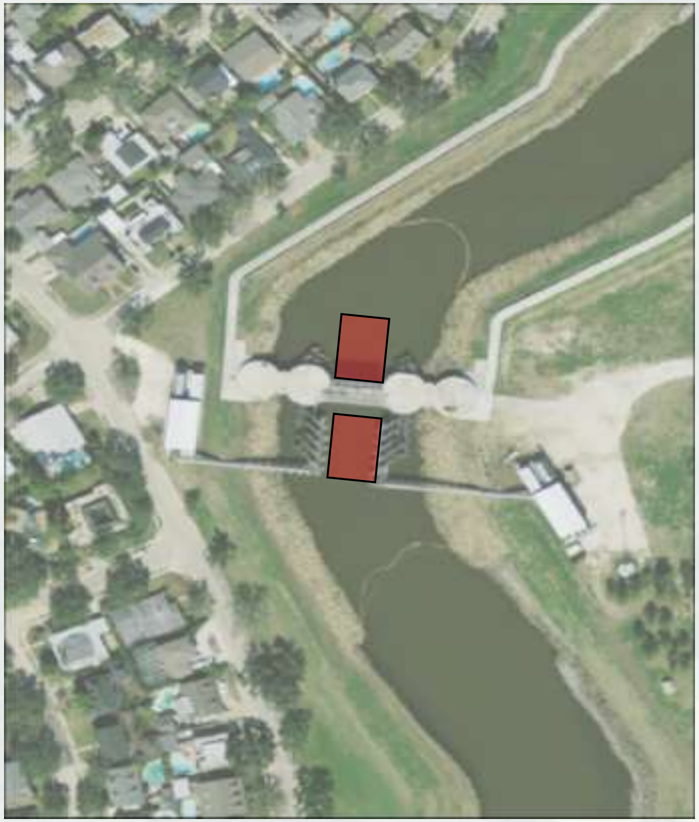
BUILDING STRONG®

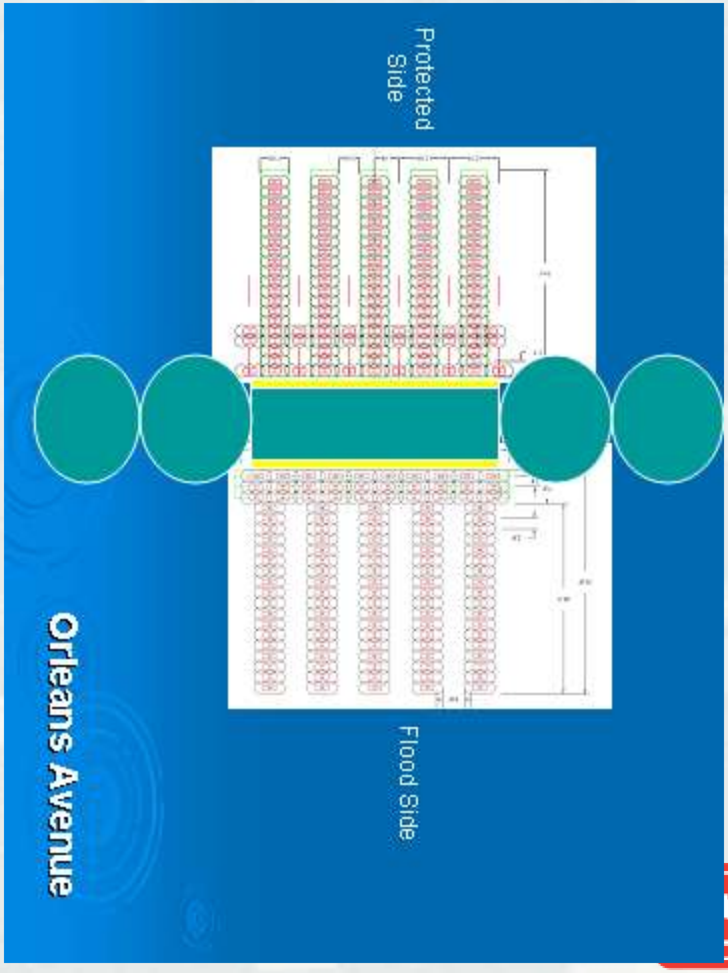
Orleans Avenue Canal



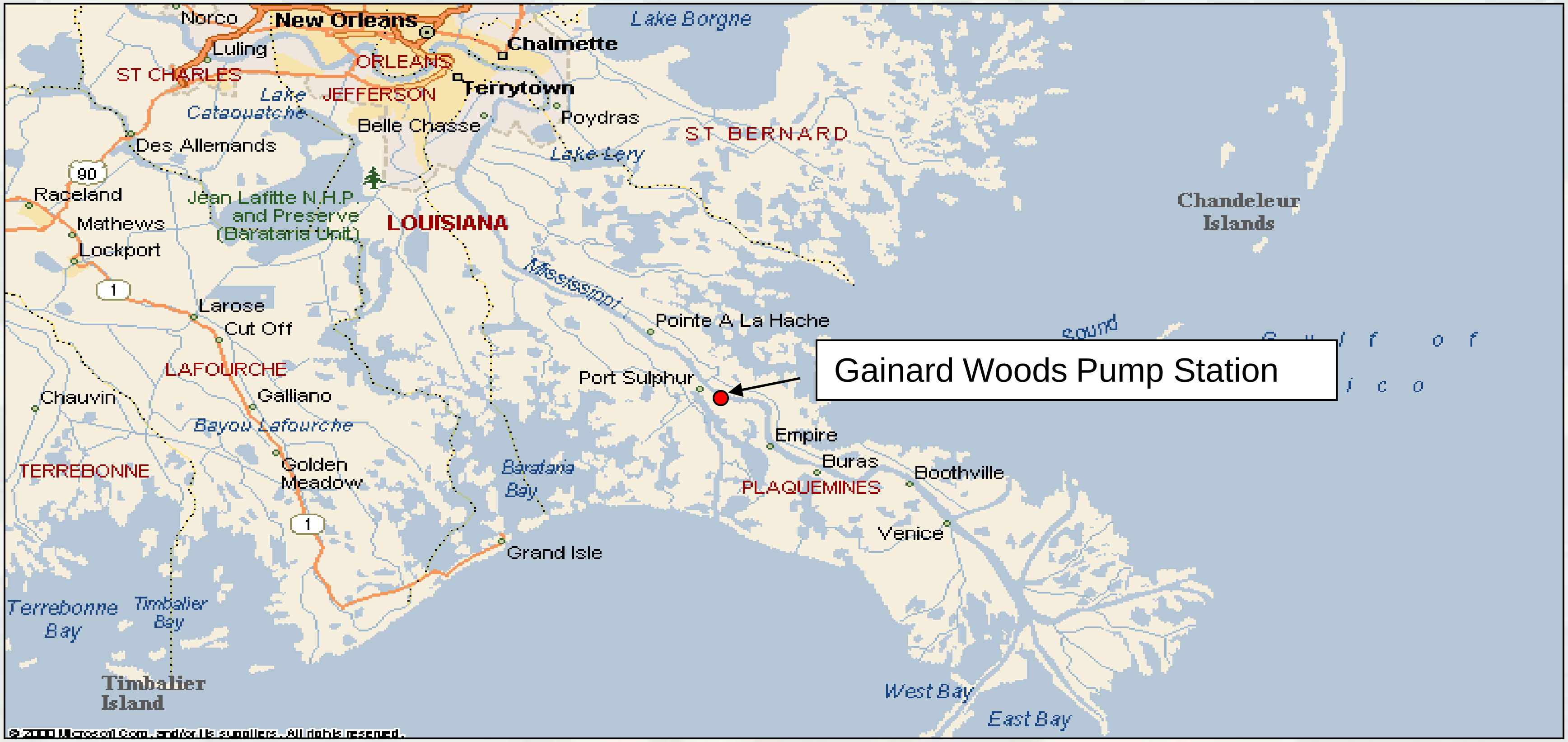
Orleans Avenue Canal
Interim Closure Structure (2006)

Orleans Avenue Canal Interim Closure Structure (2006)



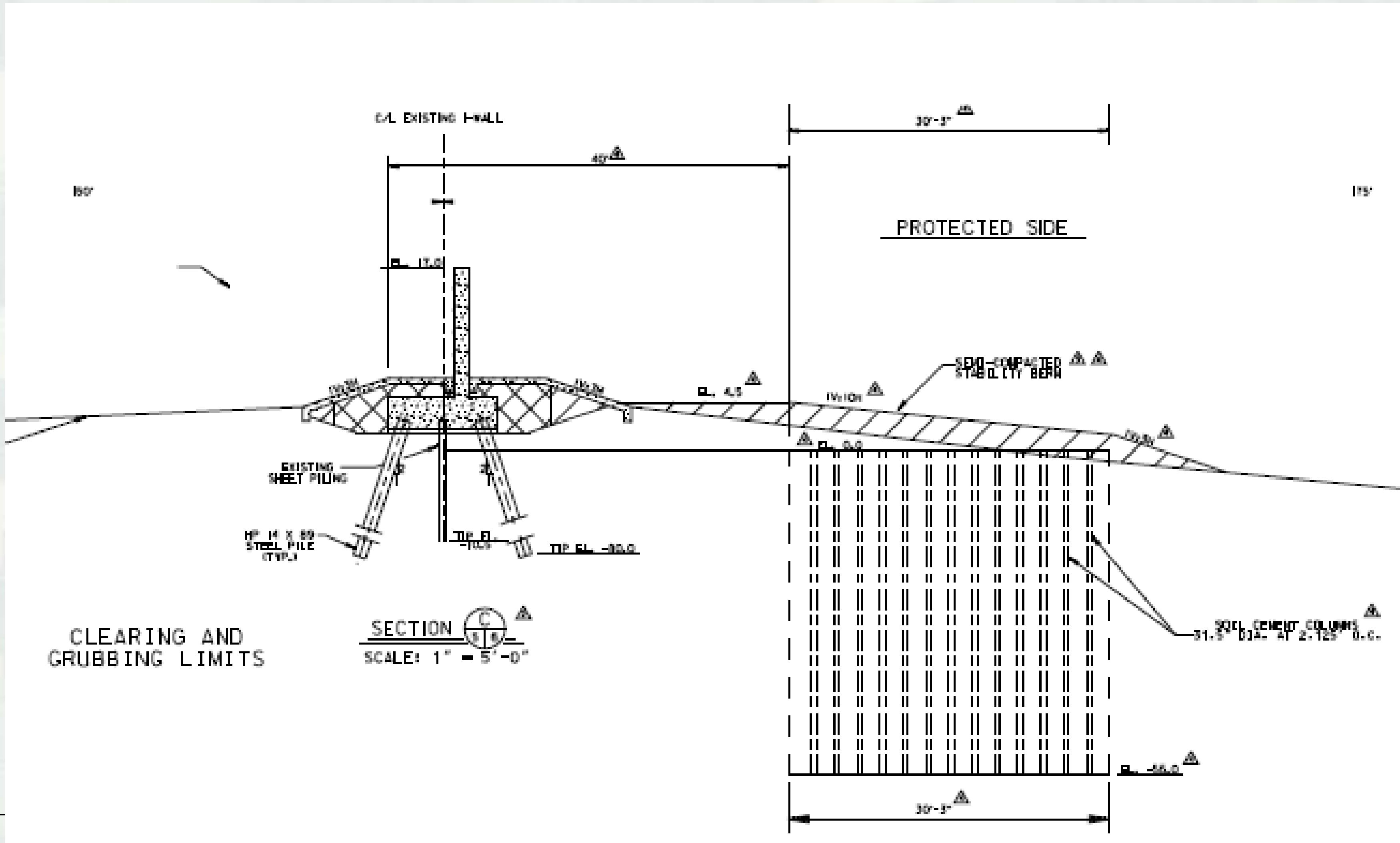


Gainard Woods Pump Station Plaquemines Parish

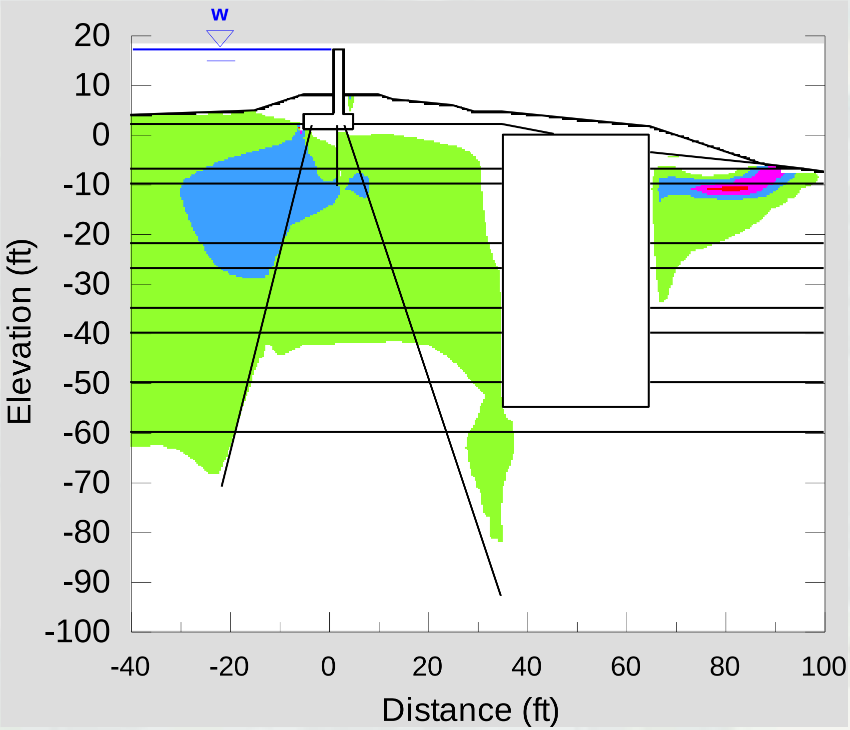


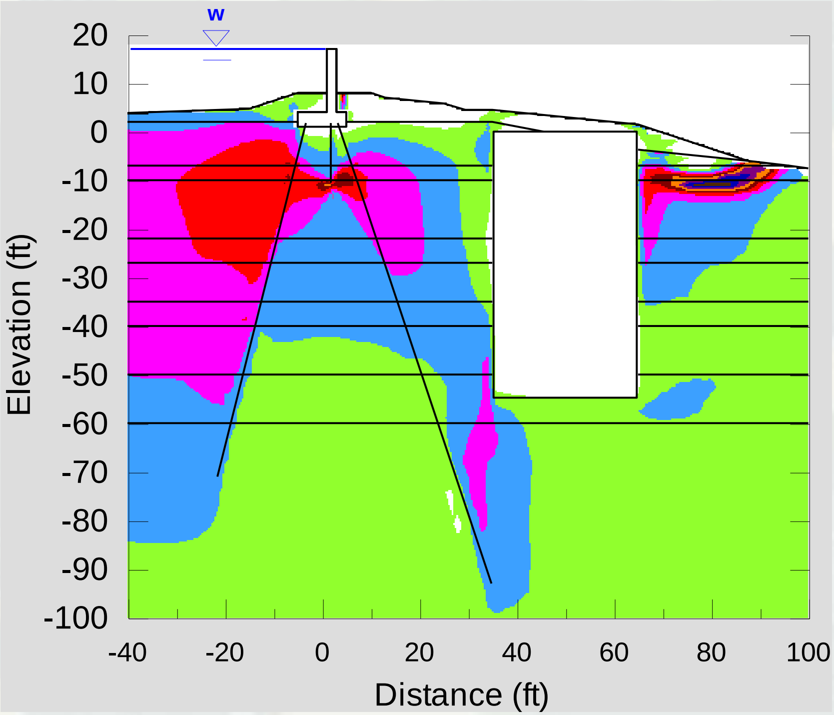
Floodwalls –
Gainard Woods Pump Station (2006)

Gainard Woods T-Wall (2006)



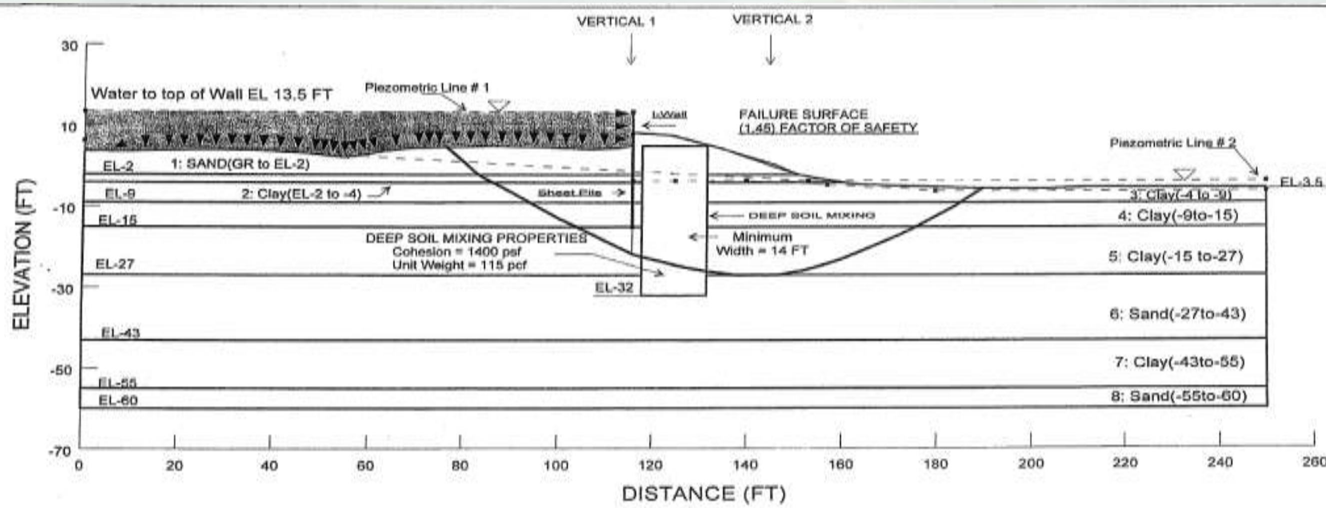
Floodwalls –
Gainard Woods Pump Station (2006)





Floodwalls –
Inner Harbor Navigation Canal (2009)

IHNC Floodwall Reinforcement (May 2009)



IHNC MOD5 - SOIL REACH B-1A: CROSS SECTION AT STATION 232+00

Soil Layer Number	Description	Friction Angle (degrees)	Vertical 1 Unit Weight (pcf)	Vertical 1 Cohesion Top (psf)	Vertical 1 Cohesion Center (psf)	Vertical 1 Cohesion Bottom (psf)	Vertical 2 Unit Weight (pcf)	Vertical 2 Cohesion Top (psf)	Vertical 2 Cohesion Center (psf)	Vertical 2 Cohesion Bottom (psf)
1	Sand	30	122	0	0	0	122	0	0	0
2	Clay	0	116	250	250	250	116	250	250	250
3	Clay	0	116	200	200	200	116	200	200	200
4	Clay	0	105	325	325	325	105	275	275	275
5	Clay	0	105	325	392	460	105	325	392	460
6	Sand	30	122	0	0	0	122	0	0	0
7	Clay	0	115	900	900	900	115	900	900	900
8	Sand	33	122	0	0	0	122	0	0	0

NOTES:

1. STABILITY ANALYSES PERFORMED BY "SPENCER PROCEDURE" USING SLOPE/W 2007.
2. PIEZOMETRIC LINE # 1 SHOWN TO MODEL PRESSURES IN FILL SANDS.
3. PIEZOMETRIC LINE # 2 SHOWN TO MODEL PRESSURES FROM BURIED BEACH SANDS.

BURNS COOLEY DENNIS, INC.
GEOTECHNICAL AND MATERIALS ENGINEERING CONSULTANTS
Ridgeland • Biloxi • Hattiesburg • Memphis

REV	DATE	DESCRIPTION	REV	DATE	DESCRIPTION

REACH III: IHNC WEST LEVEE MOD# 5
IHNC LOCK TO SEABROOK BRIDGE

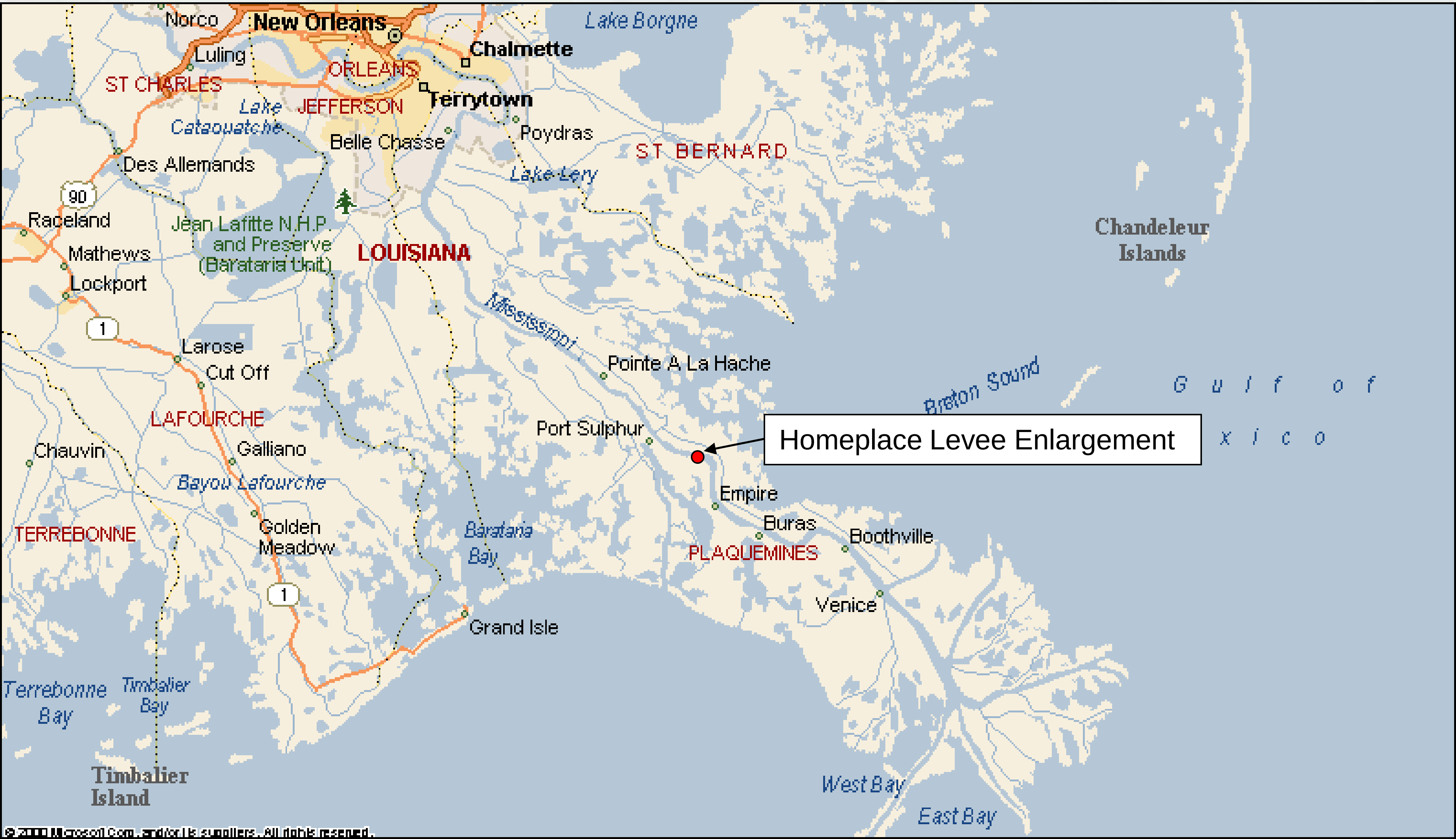
SLOPE STABILITY ANALYSES
ALTERNATIVE #3 DEEP SOIL MIXING
WATER TO TOP OF I-WALL
Reach B-1A Sta 220+00 to 233+00

DESIGNED BY: V.E.C.
DRAWN BY: V.E.C.
SCALE: AS SHOWN
FILE: MSOP3RB1AST232.GRF

DATE: 10 NOV 2008
FIGURE / DRAWING NO.
A-12

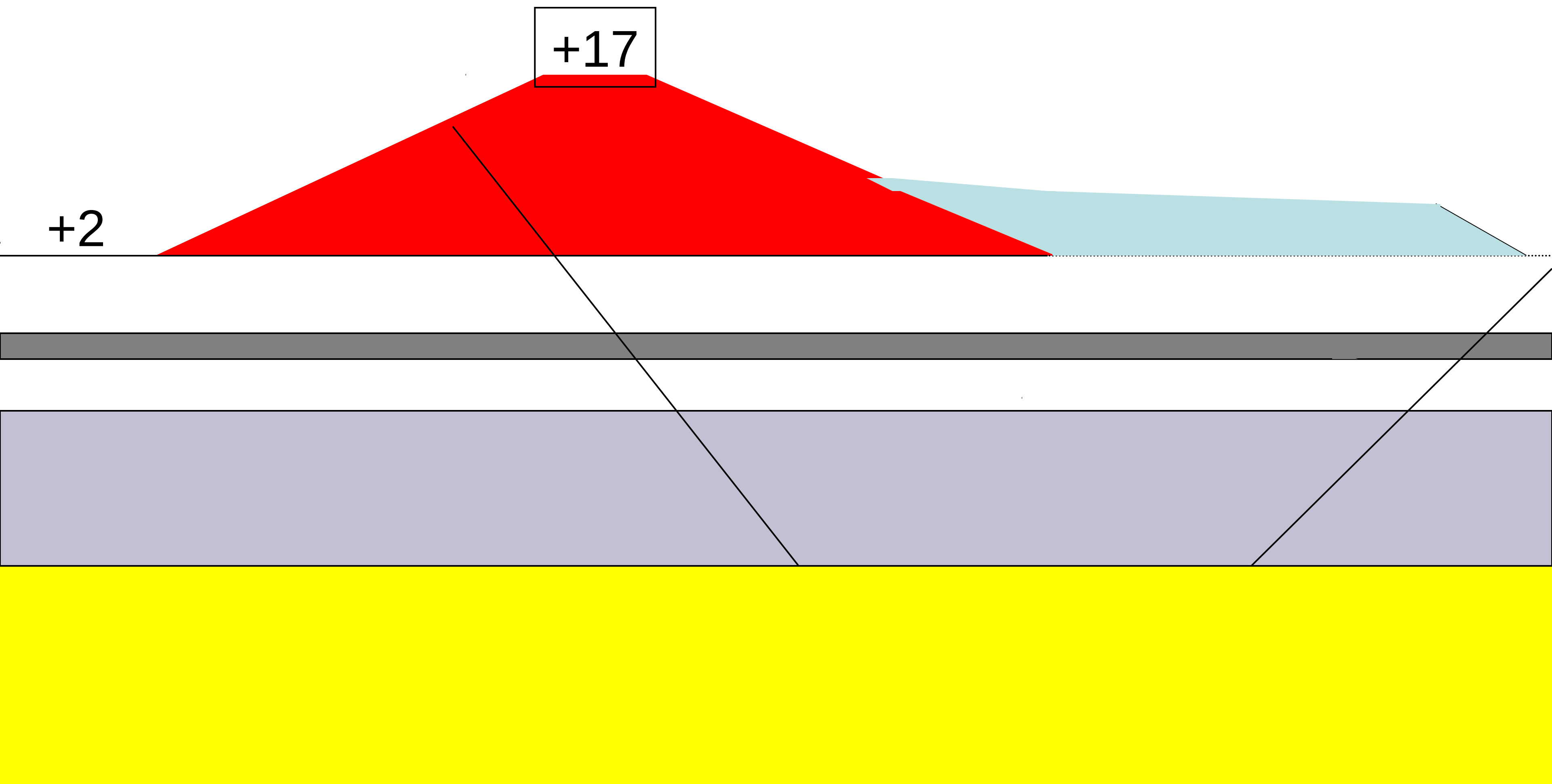
IHNC Floodwall Reinforcement (May 2009)

Homeplace Levee Enlargement Plaquemines Parish

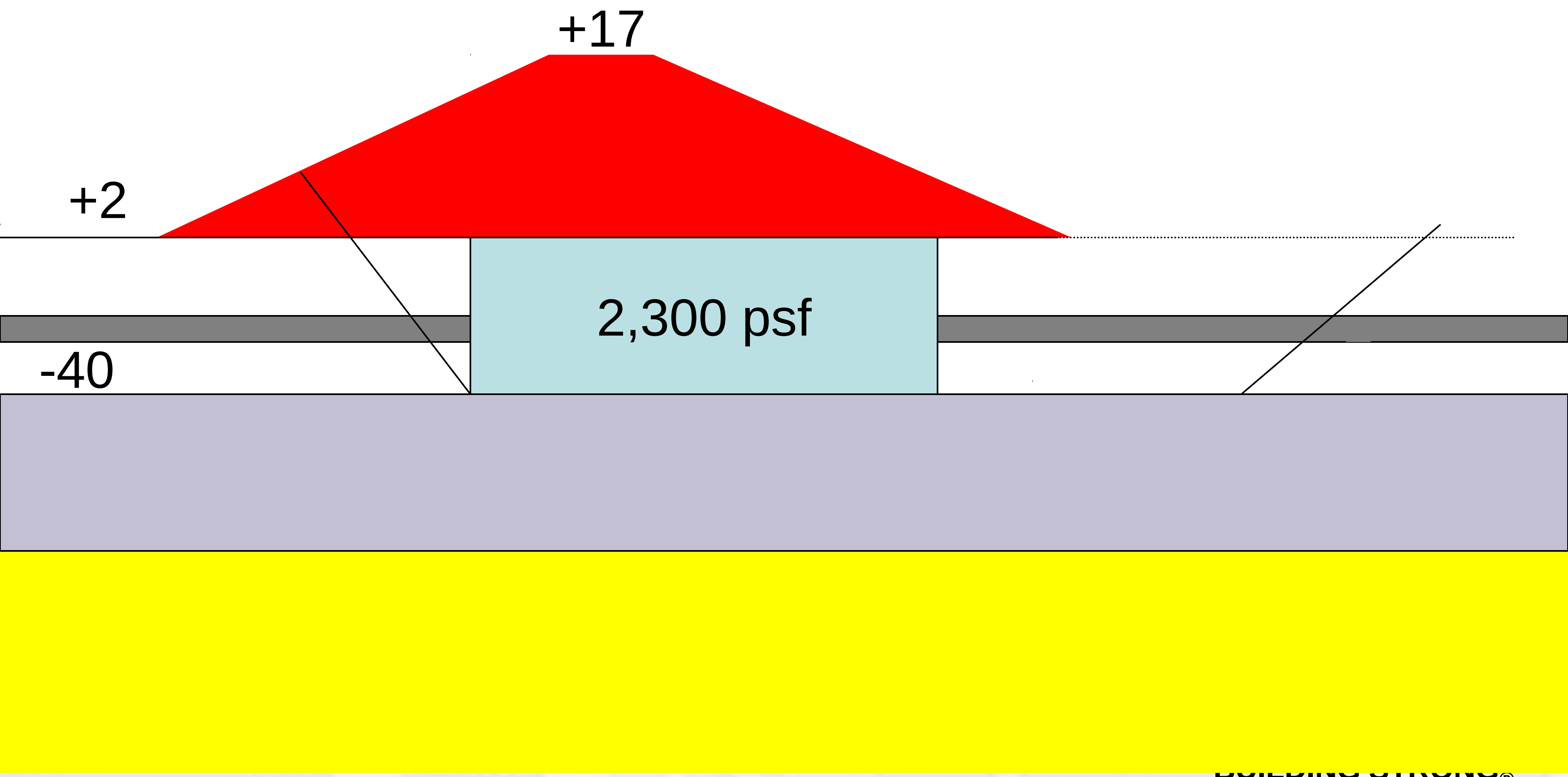


Levees –
Homeplace Levee Enlargement (P24) (2006)

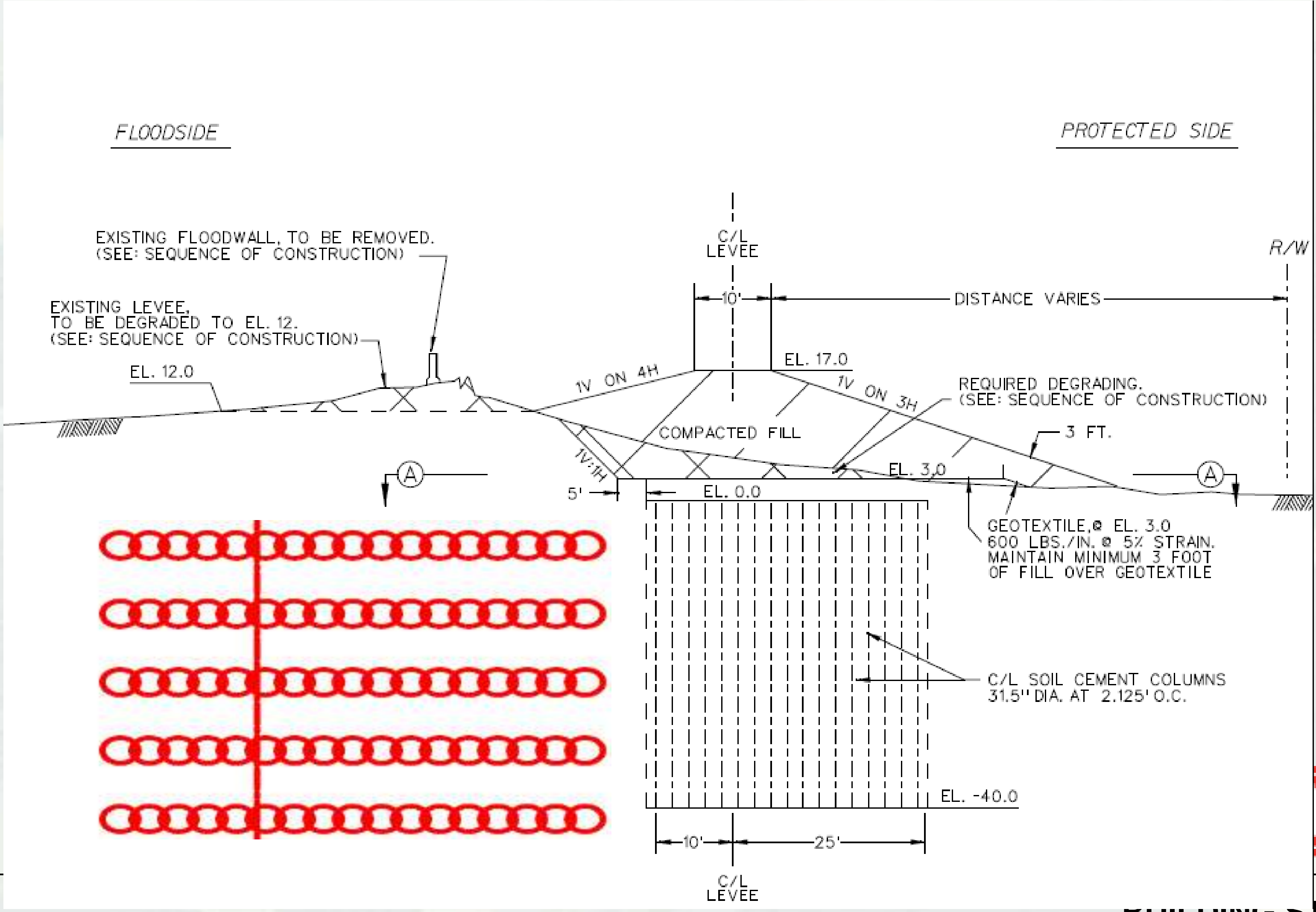
Berm needed to achieve safety factor of 1.30



To achieve SF = 1.30; Foundation improved from 270 psf to 2300 psf



Homeplace Levee Enlargement (P24) (2006)



Homeplace Levee Enlargement (P24) (2006)

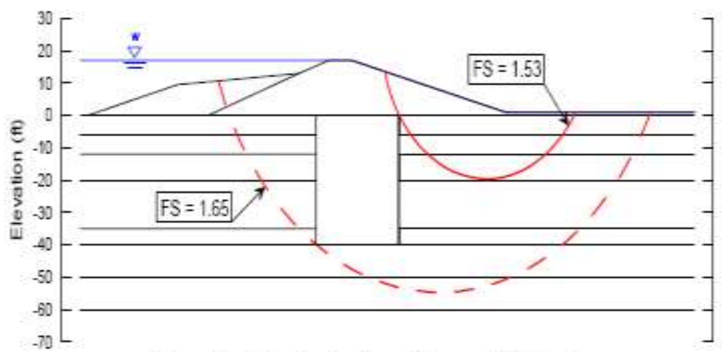


Figure 3a. Circular Surfaces, Spencer's Method

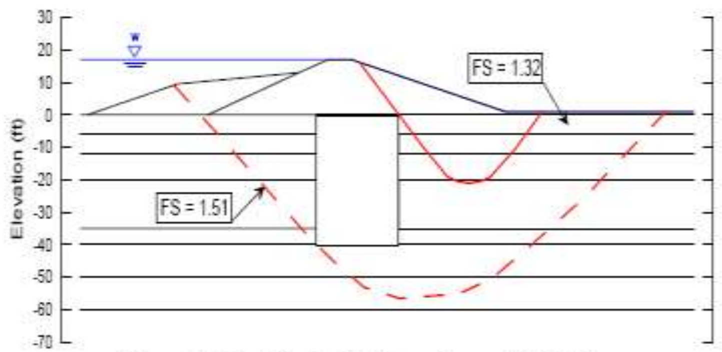


Figure 3b. Non-Circular Surfaces, Spencer's Method

Figure 3. Limit Equilibrium Analysis Failure Surfaces, UTEXAS3 Critical Surfaces

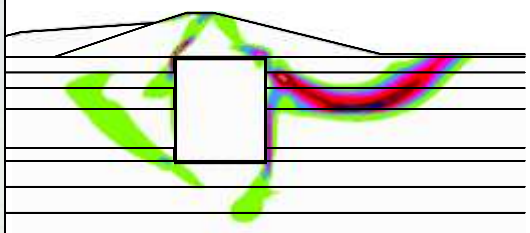


FIG 4a. Shallow Surface (FS=1.33)
100% Efficiency of Joints

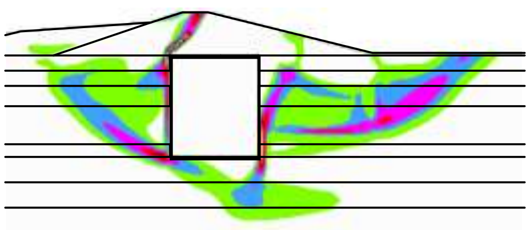


FIG 4b. Deep Surface (FS=1.51)
100% Efficiency of Joints

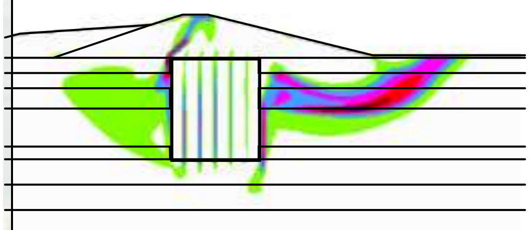


FIG 4c. Shallow Surface (FS=1.29)
0% Efficiency, 5 Vertical Joints

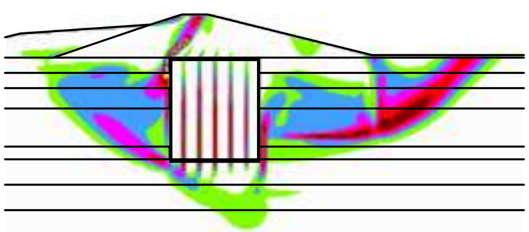


FIG 4d. Deep Surface (FS=1.37)
0% Efficiency, 5 Vertical Joints

Construction of DMM Shear Walls

Unconfined Compressive Strength Test Results for P24 DMM Cores

Number of Tests: 2081

Mean UCS: 2145 kN/m^2 (311 psi)

Standard Deviation: 1259 kN/m^2 (183 psi)

Coefficient of Variation: 0.59

UCS = 690 kN/m^2 (100 psi) was used for design

P-24 Final Section

Design Guide for Levees and Floodwall Stability Using DM Shear Walls

- Limit equilibrium analysis
- Combines sliding, overturning and internal shear analyses
- Uses reliability factors for material and stability safety factors
- Uses CDIT 2002 as basis for analysis

DESIGN GUIDE

FOR

LEVEE AND FLOODWALL STABILITY USING DEEP-MIXED WALLS

by

George Filz and Eddie Templeton

February 10, 2009

QA/QC Testing

- Reverse Column Pentetration Testing
- Pressuremeter
- Cone Penetrometer Testing
- Borehole Camera
- Exhumation (Exposure, Excavation)
- Sonic Drilling
- Coring and Compressive Strength Testing

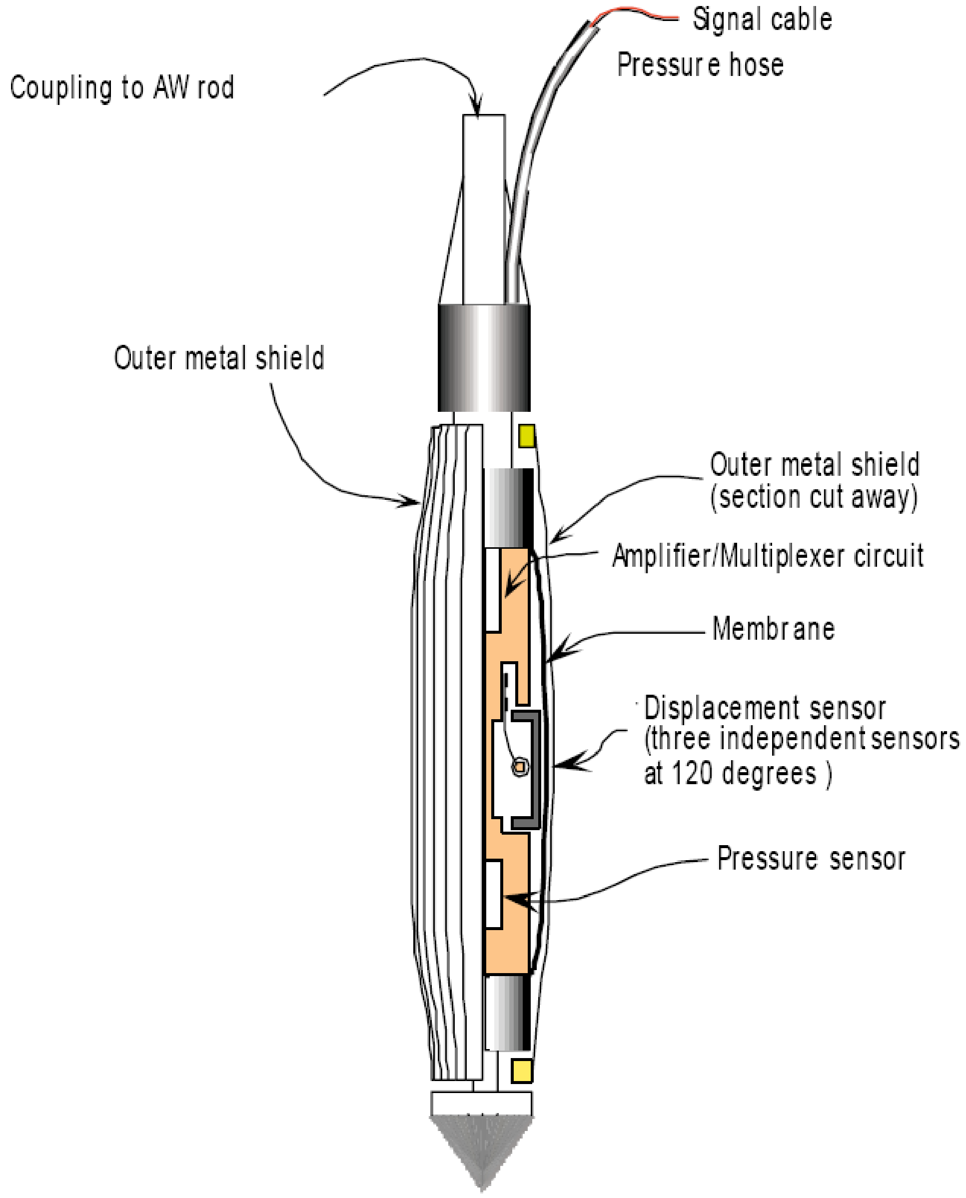
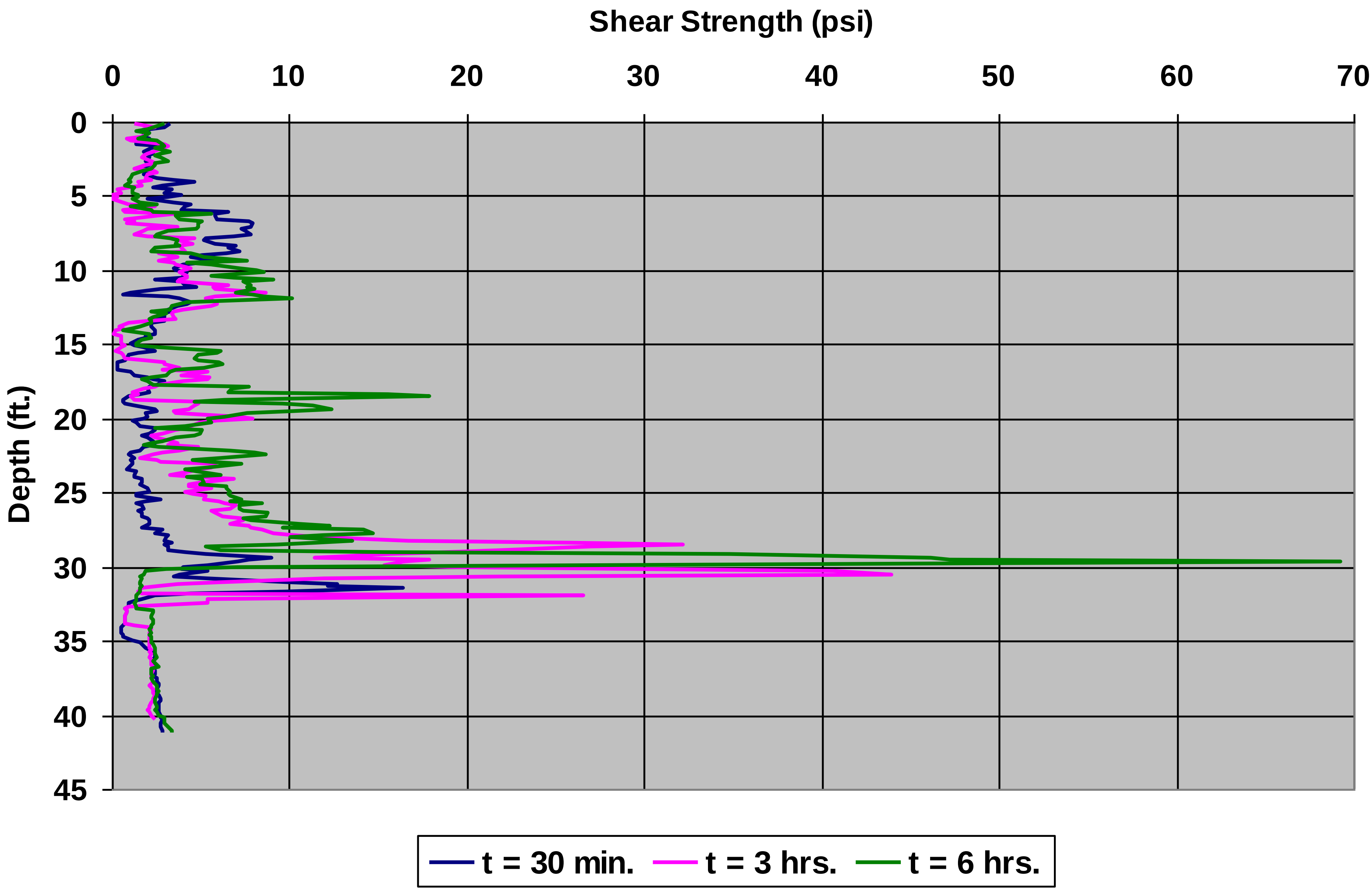


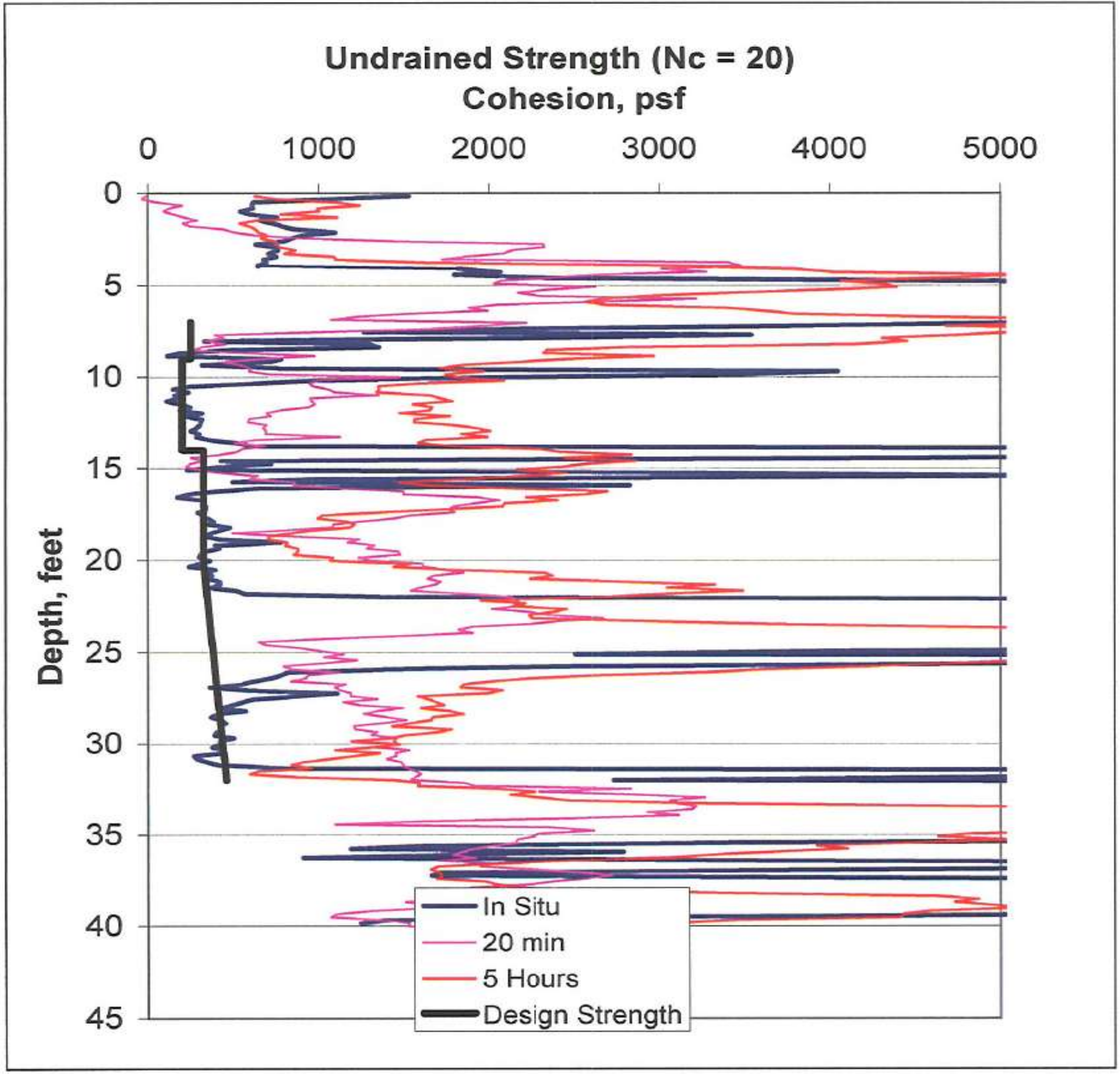
Fig. 1. Schematic details of the pressuremeter

Pressuremeter

- Use to great success during 2003 Test Section
- Utilized for Q/A and Q/C in 2008
- Can be used to determine limit pressure, which can be obtain shear strength
- Limit pressure is assumed to occur when volume is doubled
- Poisson’s ratio assumed to be 0.33
- Column Modulus can also be determined

IHNC CPT Data





Undrained Strength (Nc = 20)
Cohesion, psf
0
1000
2000
3000
4000
5000
0
5
10
15
20
25
30
35
40
45
Depth, feet
In Situ
20 min
5 Hours
Design Strength


+000.0f

Column Exhumation

Sonic Drilling Rig

Sonic Drilling Cores

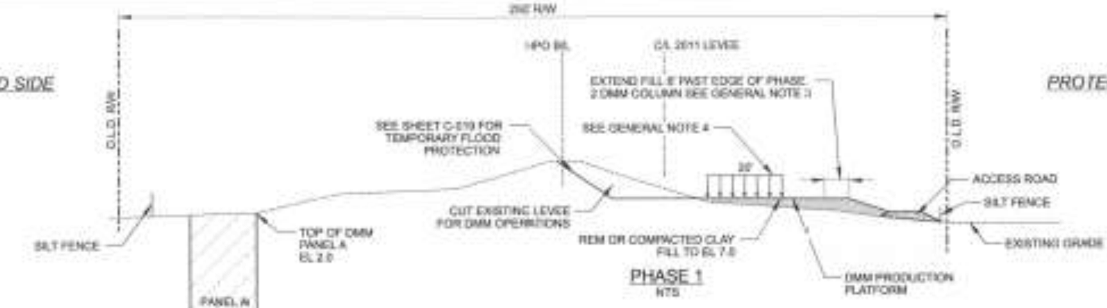
Wet Grab Sampling

LPV – 111

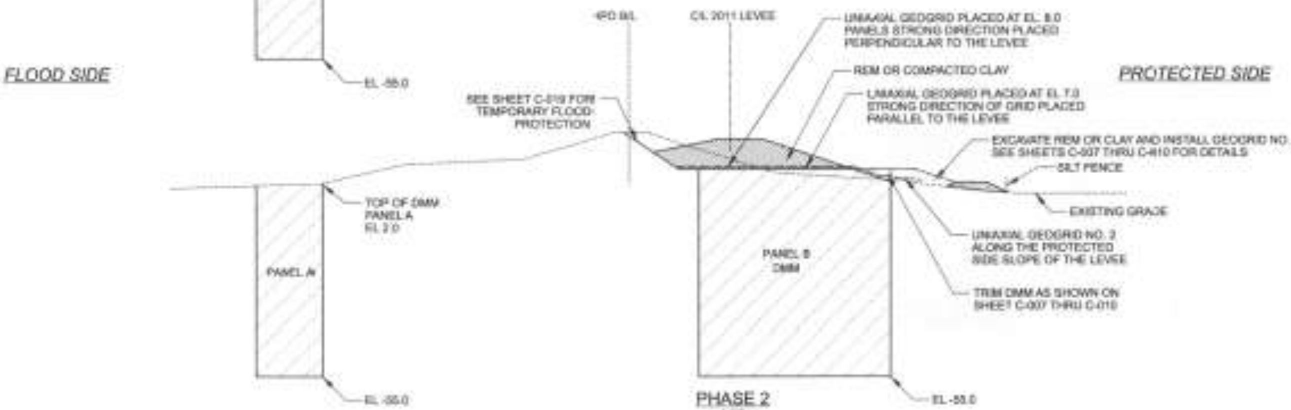
Lake Pontchartrain
EASTERN NEW ORLEANS
Bayou Sauvage National Wildlife Refuge
Chef Menteur Pass
LPV 111
IHNC Surge Barrier
Gulf Intracoastal Waterway
GIWW
IHNC
Lake Borgne
Bayou Bienvenue
Mississippi River-Gulf Outlet
Mississippi River
ARABI
CHALMETTE
Breakwater
Lakefront Airport
Bayou Mercier

LPV - 111

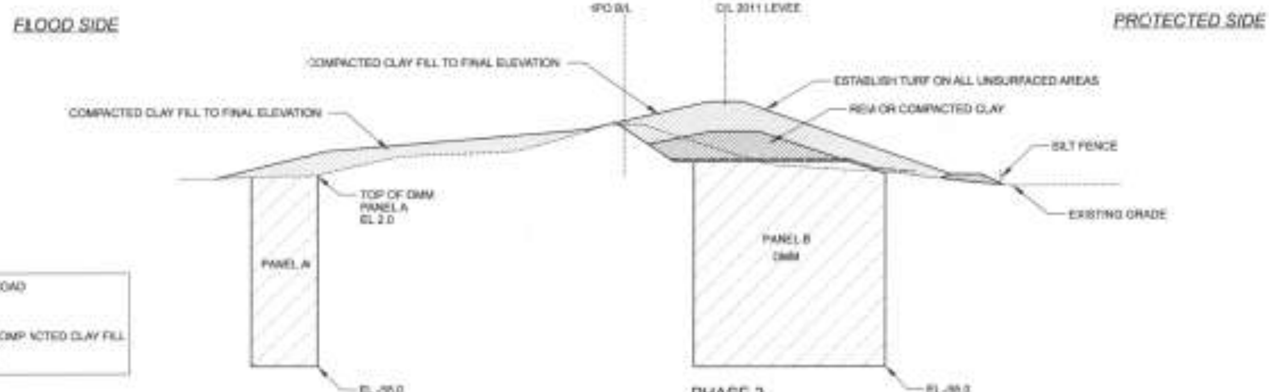
- Largest Deep Soil Mixing Project in the World
- 1.7 million cubic yards of soil will be treated.
- 5.3 miles of Levee will be raised from 17 feet to 28 feet
- Soil mixing extends to -67 ft deep and varies in width from 54 ft to 98 ft



PHASE 1
NTS



PHASE 2
NTS



PHASE 3
NTS

PHASE 1

1. CLEAR NEW LEVEE FOOTPRINT
2. INSTALL ACCESS ROAD
3. FILL PROTECTED SIDE OF LEVEE TO EL. 7.0 IN LIFTS ACCORDING TO THE EMBANKMENT SPECIFICATION AND WITH THE RATE OF FILL PLACEMENT CONTROLLED ACCORDING SPECIFICATION 31 24 00.00 12, EMBANKMENT.
4. INSTALL FLOOD SIDE DMM PANEL A - PRIOR TO PHASE 2

PHASE 2

1. DMM TO EL -64.0
2. INSTALL GEOGRID NO. 1 AT EL 7.0 TRIM PROTECTED SIDE CORNER OF DMM PANEL AS SHOWN ON SHEET C-007 THRU C-010.
3. PLACE REM OR COMPACTED CLAY TO LIMITS SHOWN ON C-007 THRU C-010.
4. INSTALL UNIAXIAL GEOGRID NO. 2 AT EL 8.0. PLACE GEOGRID NO. 2 ALONG THE PROTECTED SIDE SLOPE OF THE LEVEE.

PHASE 3

1. FILL TO FINAL ELEVATION AFTER STRENGTH OF DMM HAS REACHED REQUIRED STRENGTH IN SPECIFICATION 31 21 00.00 12
2. ESTABLISH TURF ON ALL UNSURFACED AREAS PER SPECIFICATIONS 32 92 19.04 12

LEGEND

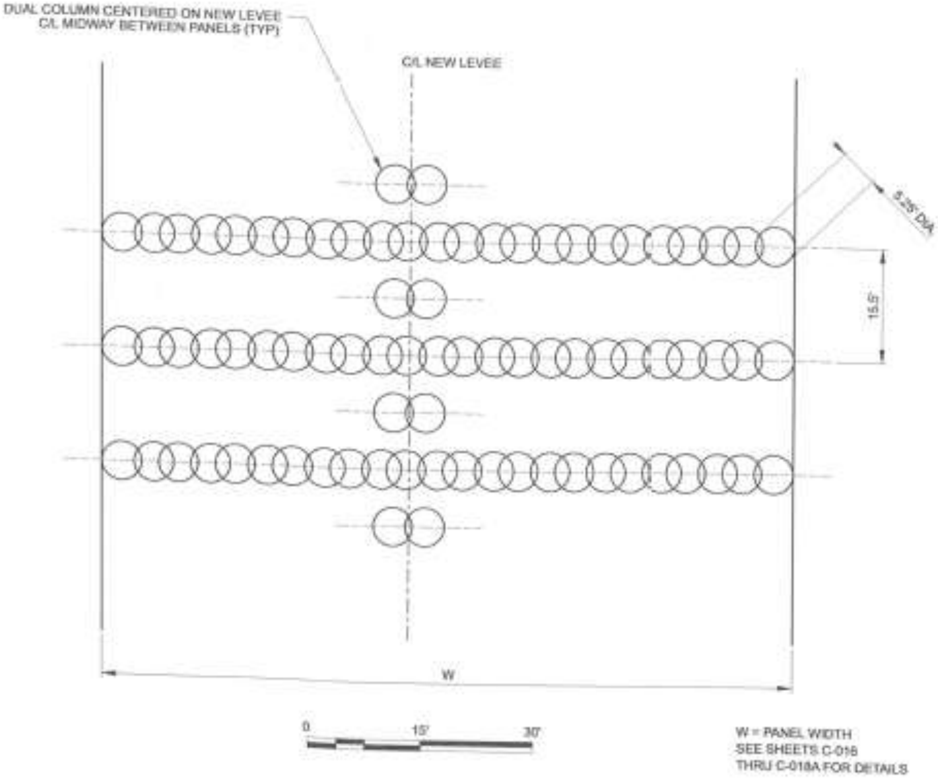
- ACCESS ROAD
- DMM
- REM OR COMPACTED CLAY FILL
- CLAY FILL

GENERAL NOTES:

1. SEE SHEET C-007 THRU C-010 FOR DETAILED TYPICAL SECTIONS.
2. SEE SHEET G-003 FOR ABBREVIATIONS AND LEGEND.
3. THE DMM PRODUCTION PLATFORM IS THE WIDTH OF THE DMM PANELS PLUS 8' EITHER SIDE.
4. THE DMM PRODUCTION PLATFORM IS DESIGNED FOR A MAXIMUM SURCHARGE LOADING OF 350 PSF IN A 20-FT WIDE X 40-FT LONG ZONE ADJACENT TO THE PROTECTED SIDE EDGE OF THE PLATFORM. CONTRACTOR SHALL SUBMIT FOR REVIEW AND APPROVAL CALCULATIONS DEMONSTRATING THAT THE STABILITY OF THE PLATFORM MEETS THE REQUIREMENTS OF SPECIFICATION SECTION 31 24 00.00 12, EMBANKMENT IF THE CONTRACTOR PROPOSES TO PLACE SURCHARGE LOADS EXCEEDING THAT ASSUMED IN THE DESIGN.

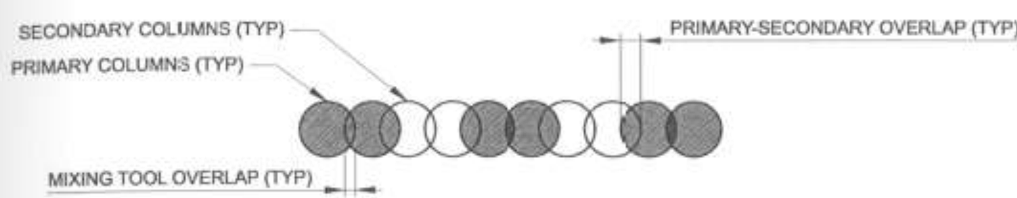
11B PHASING PLAN

B/L STA. 1063+35.33 TO B/L STA. 1105+73.57



TYPICAL DEEP-MIX PANEL ARRANGEMENT
PLAN VIEW, 12A AND 12B

PRIMARY COLUMN IS INSTALLED BEFORE SECONDARY



TYPICAL DUAL COLUMN OVERLAP


CAT


05/03/2010


CAT
05/03/2010


05/03/2010


CAT
05/03/2010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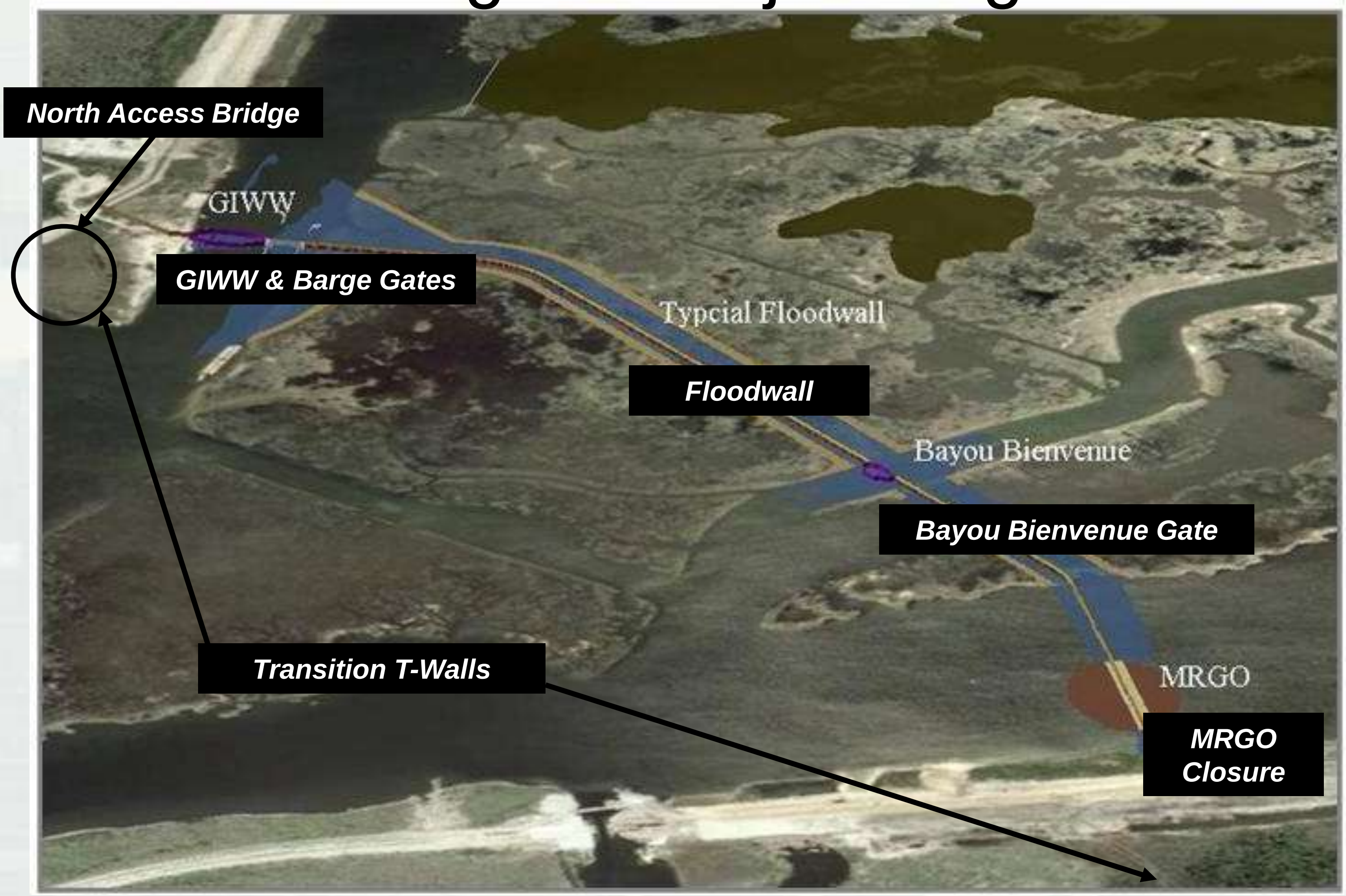
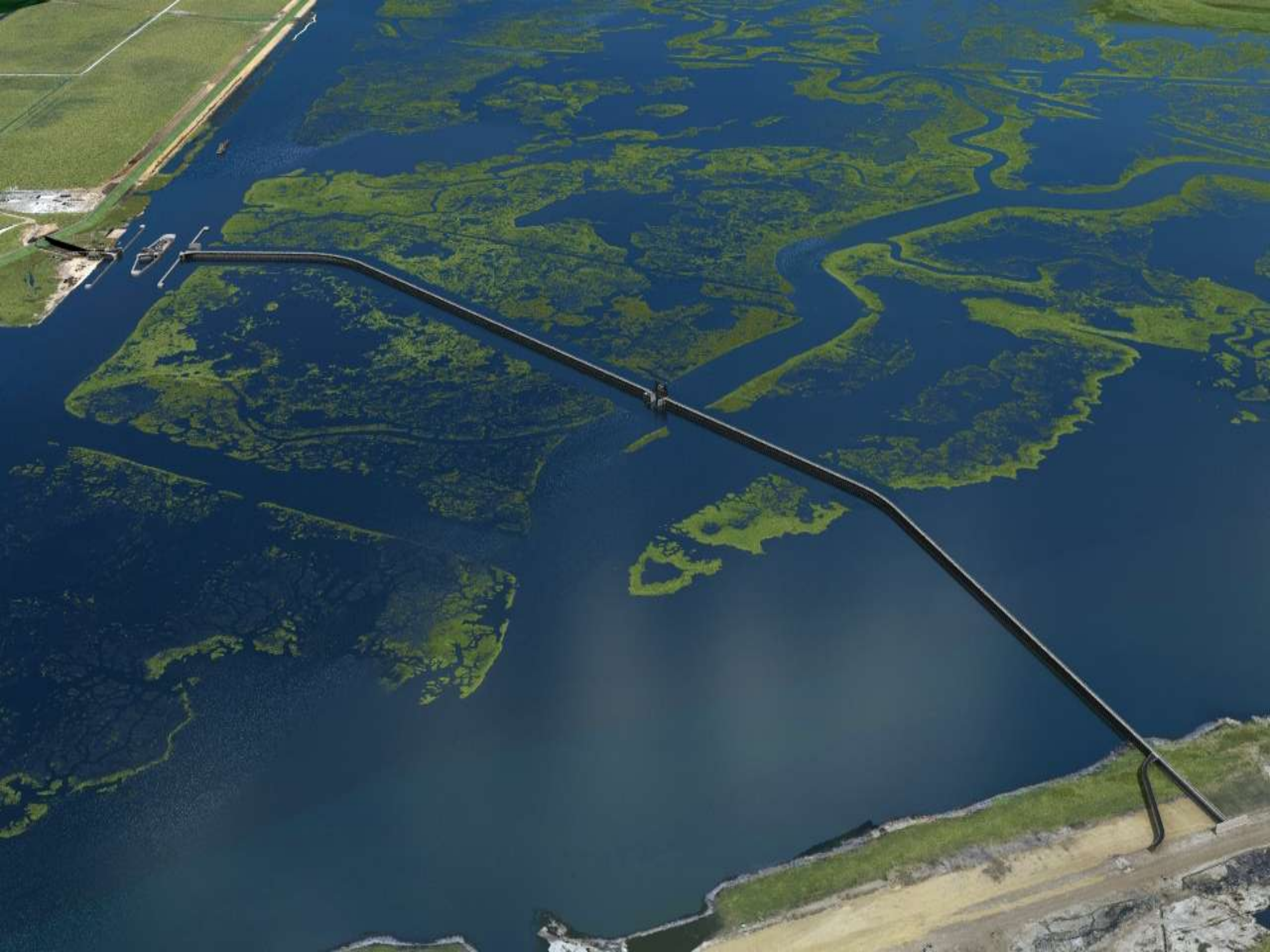
05/03/2010

Large Hurricane Risk Reduction Structures

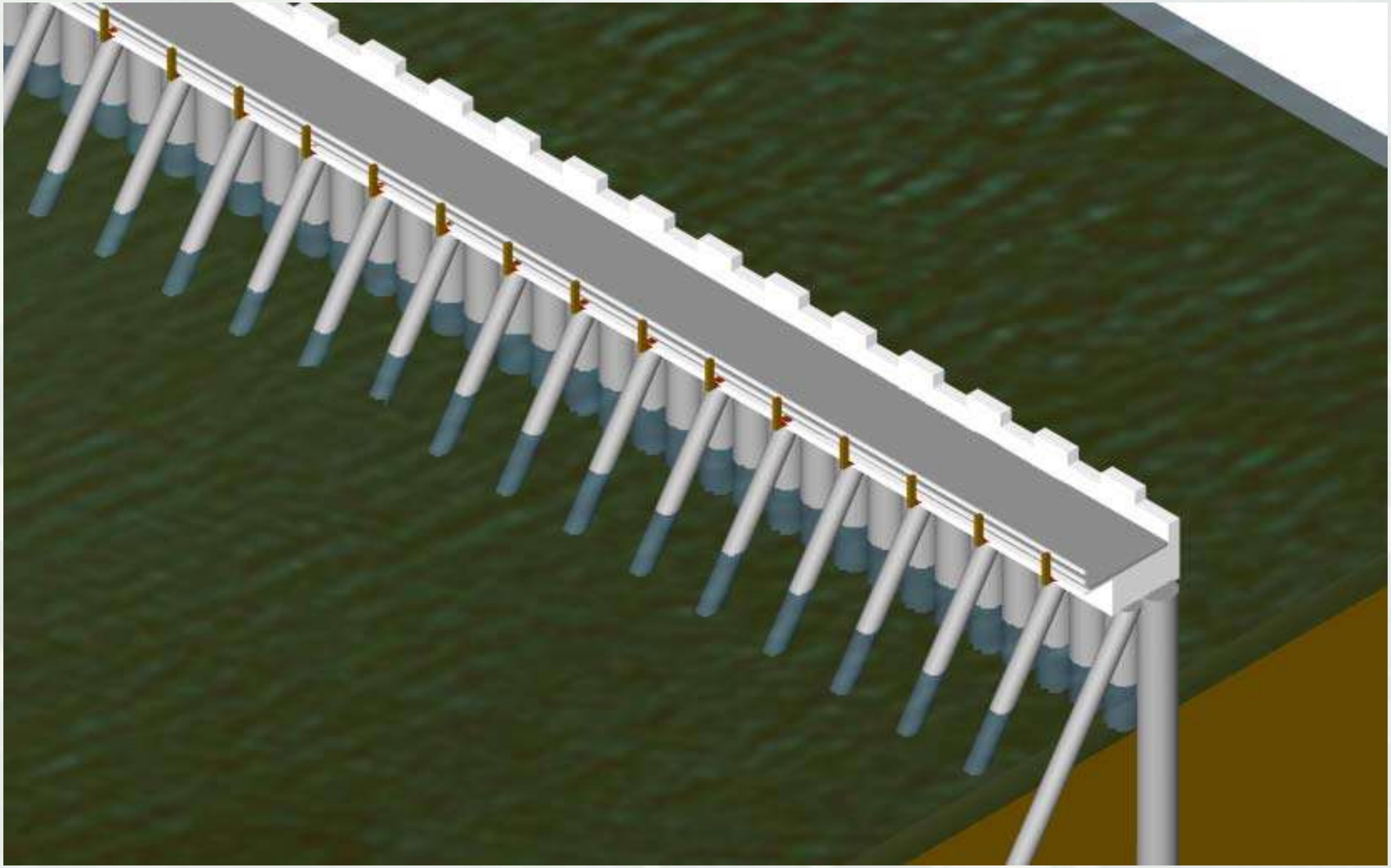
IHNC SURGE BARRIER

Lake Borgne– Project Alignment





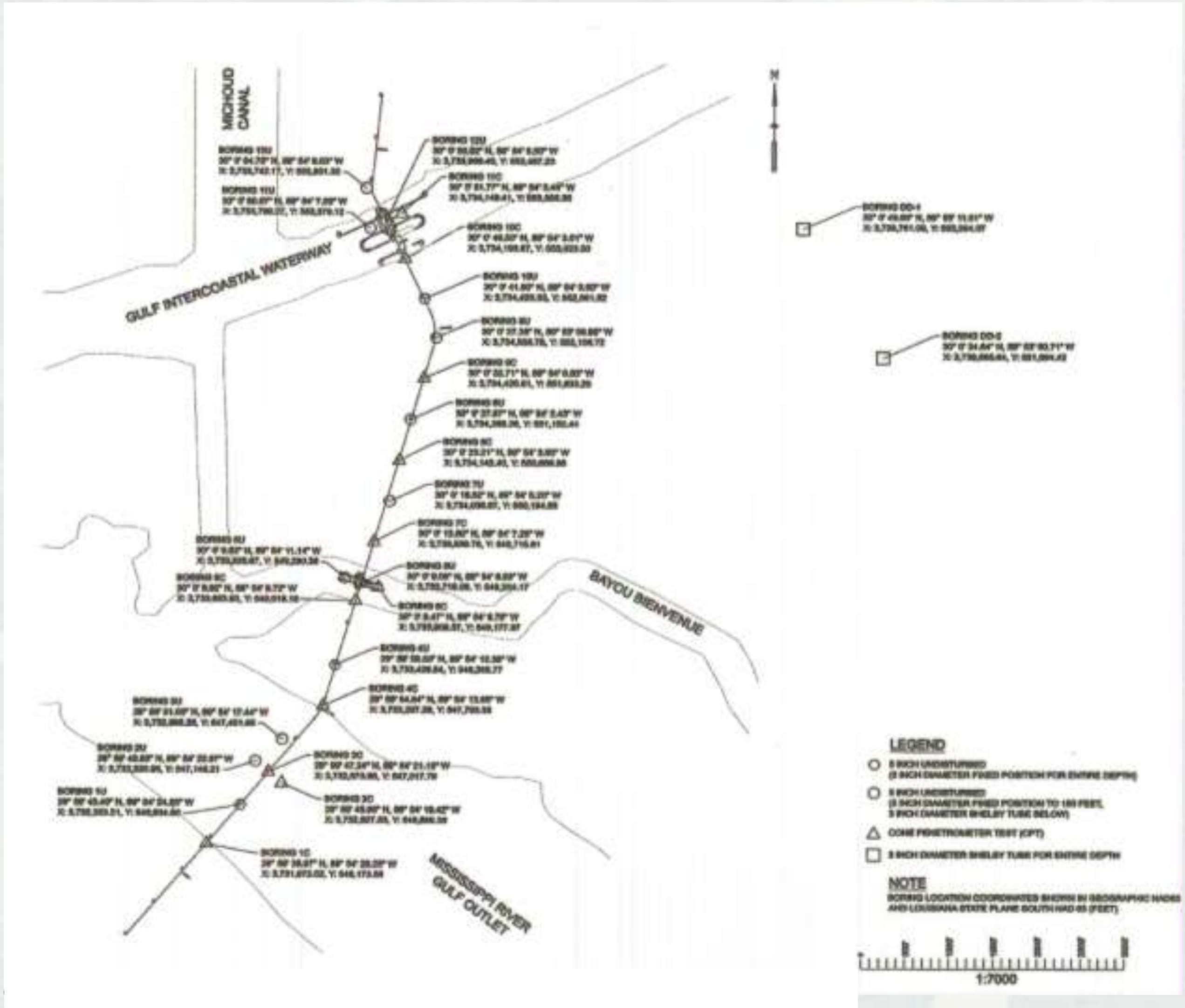
Barrier Flood Wall



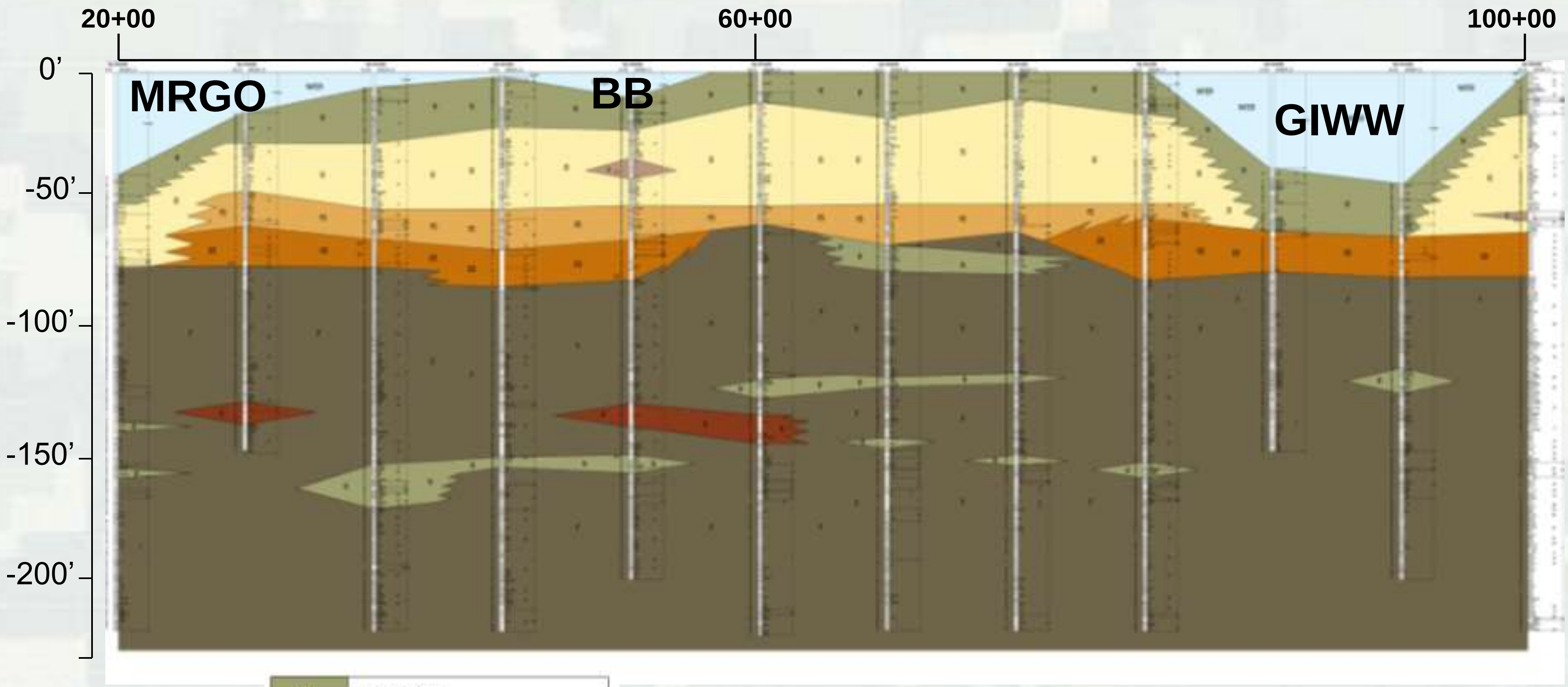
GIWW Barge / Sector Gate (Conceptual)

Bayou Bienvenue Vertical Lift Gate (Conceptual)

Boring Locations



Geologic Profile

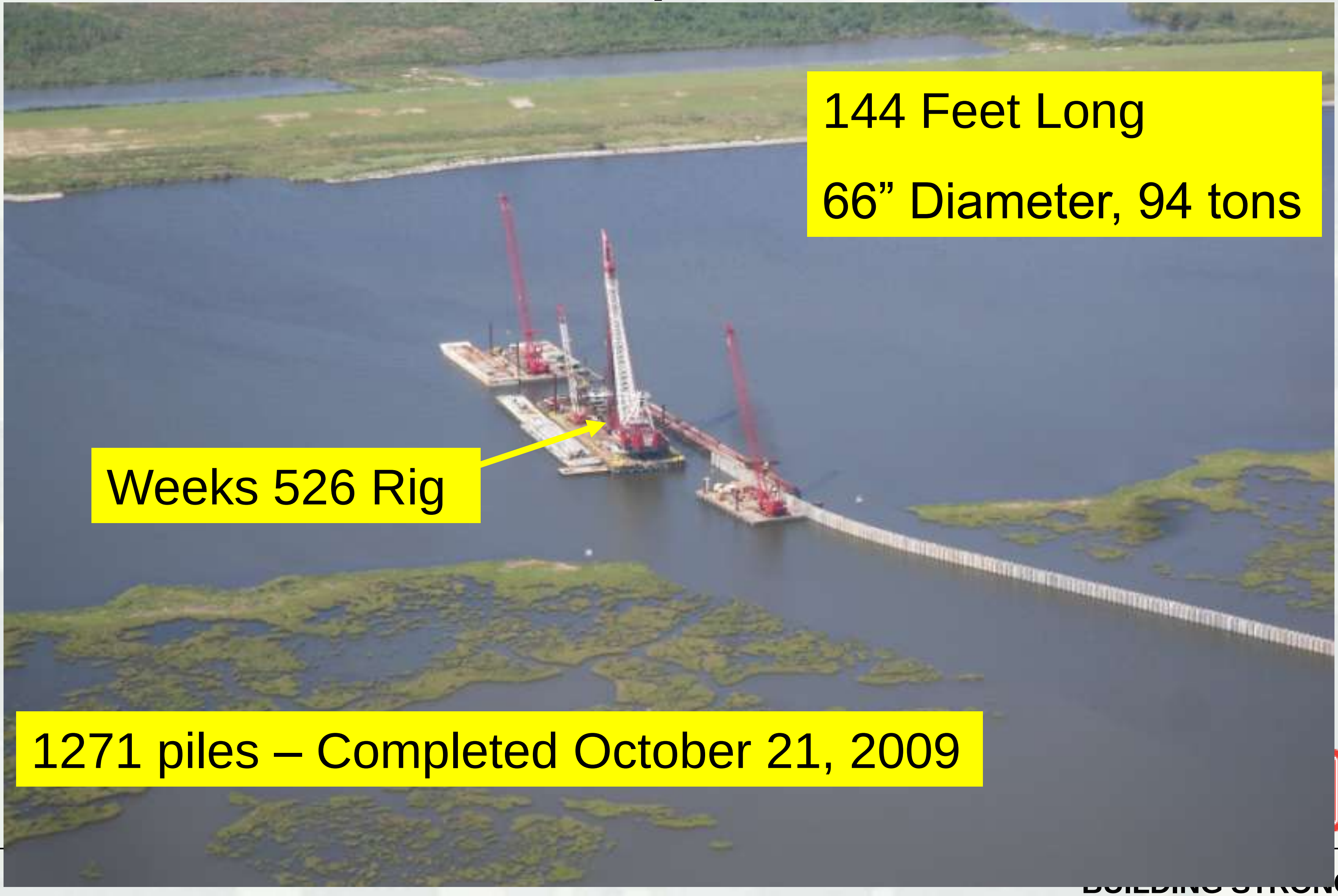


M	MARSH
ID	INTERDISTRIBUTARY
IDE	INTRADELTA
PD	PRODELTA
B	BEACH
R	REEF
P	PLEISTOCENE

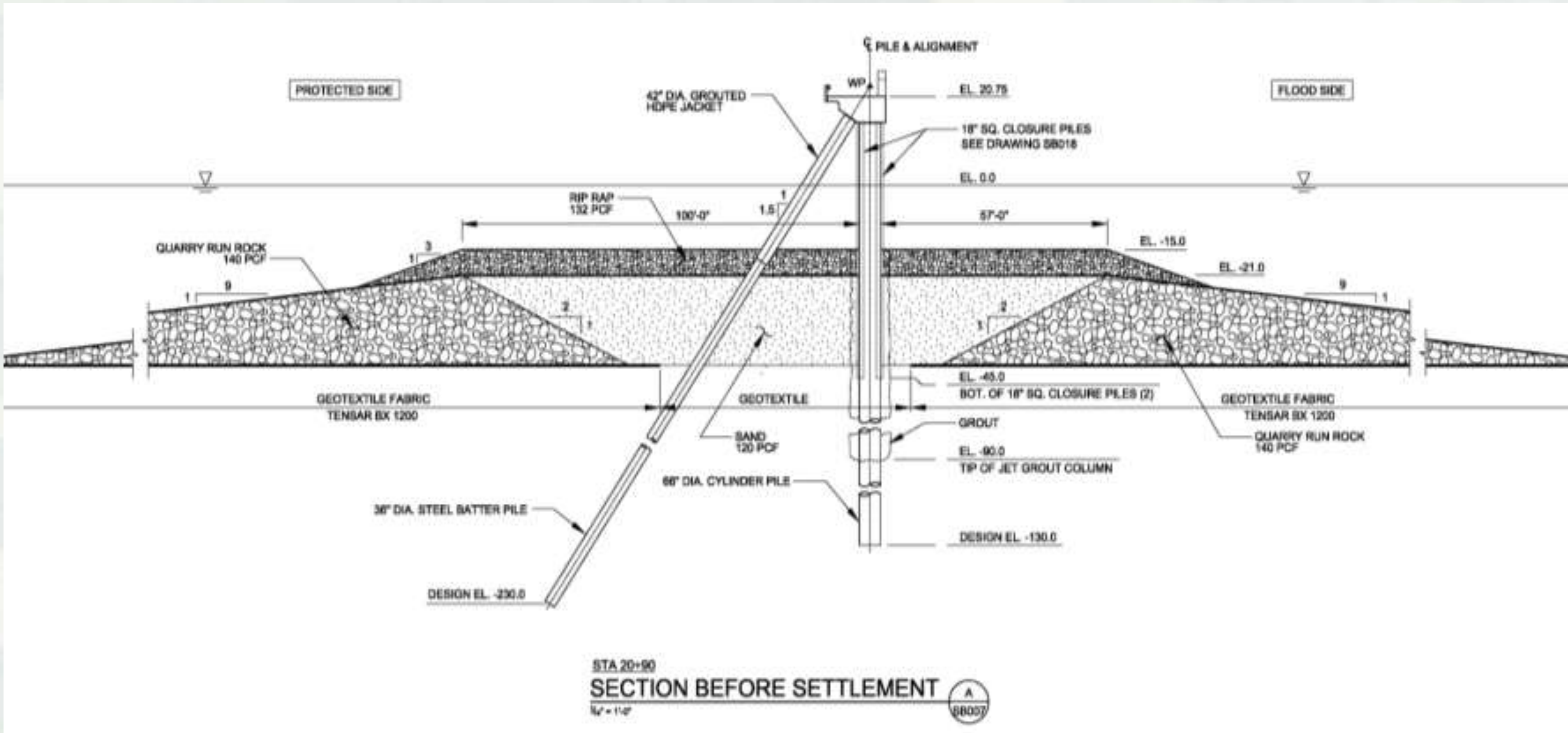
Design Investigations

- Pile Load Test
- Lateral Load Test
- Non-linear Incremental Structural Analysis (NISA)
- Physical Model – GIWW Sector Gate
- Physical Model – Barrier Wall
- Navigation Simulation – Gate Width Study
- Approach Wall Vessel Impact Analysis
- Navigation Physical Guidewall Model
- USCG Navigation Risk Assessment
- Long-term Instrumentation Plan

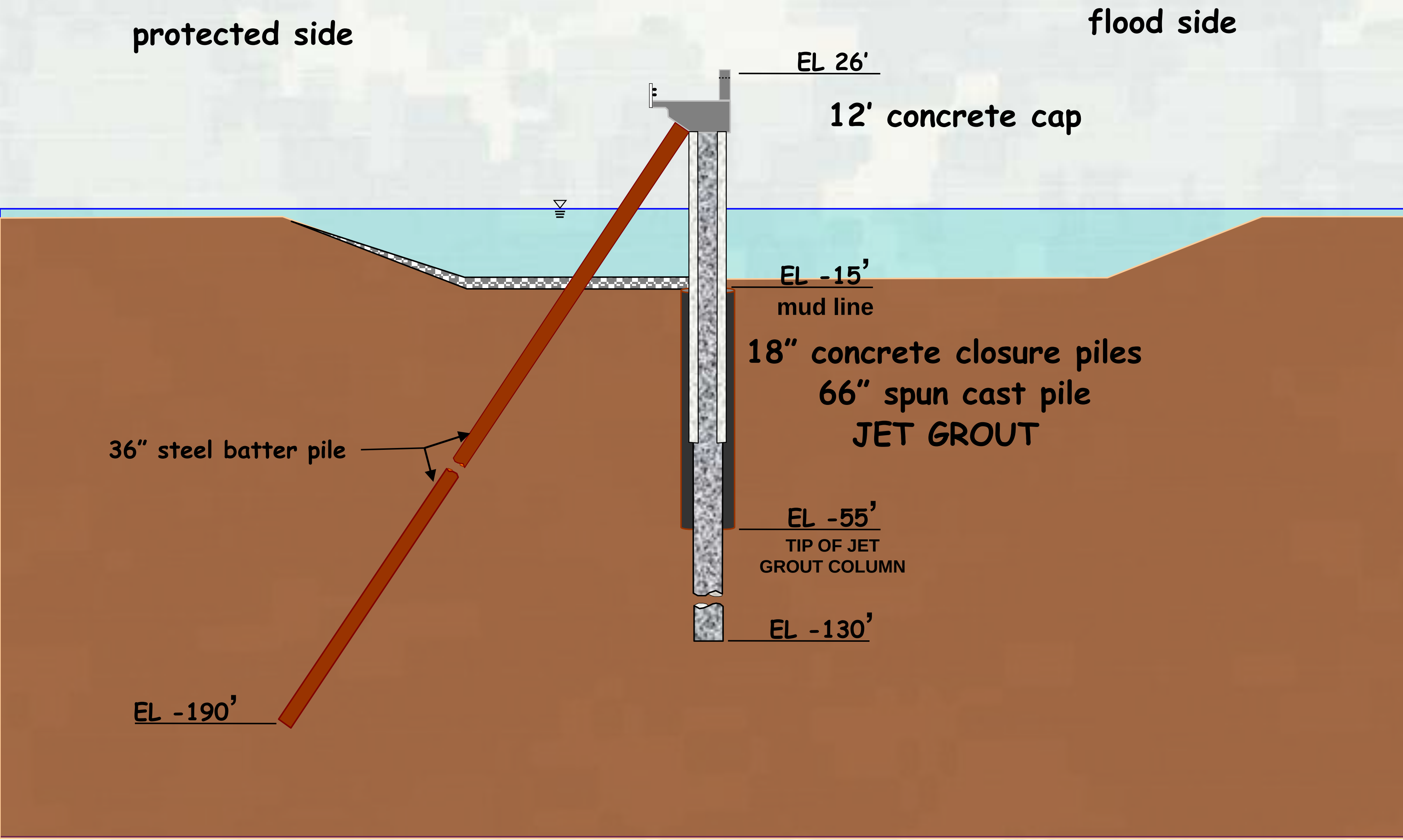
Soldier Pile Placement – Complete!



MRGO Section



Sand Fill at MRGO


protected side
flood side
EL 26'
12' concrete cap
EL -15'
mud line
18" concrete closure piles
66" spun cast pile
JET GROUT
36" steel batter pile
EL -55'
TIP OF JET
GROUT COLUMN
EL -130'
EL -190'

Spin Casting

Spun Cast Piles

Soldier Piles

Post Tensioning

Pile Load Test

18” Closure Piles & Jet Grouting

Soldier, Closure, Batter Piles

66" Concrete Pile Clean Out

Drill bit removes the mud from inside the pile

Grout Bag Placement

Batter Piles

Precast Caps

17 Feet Long, 96 Tons

Parapet

Interesting Quantity Facts

The IHNC Project Involves:

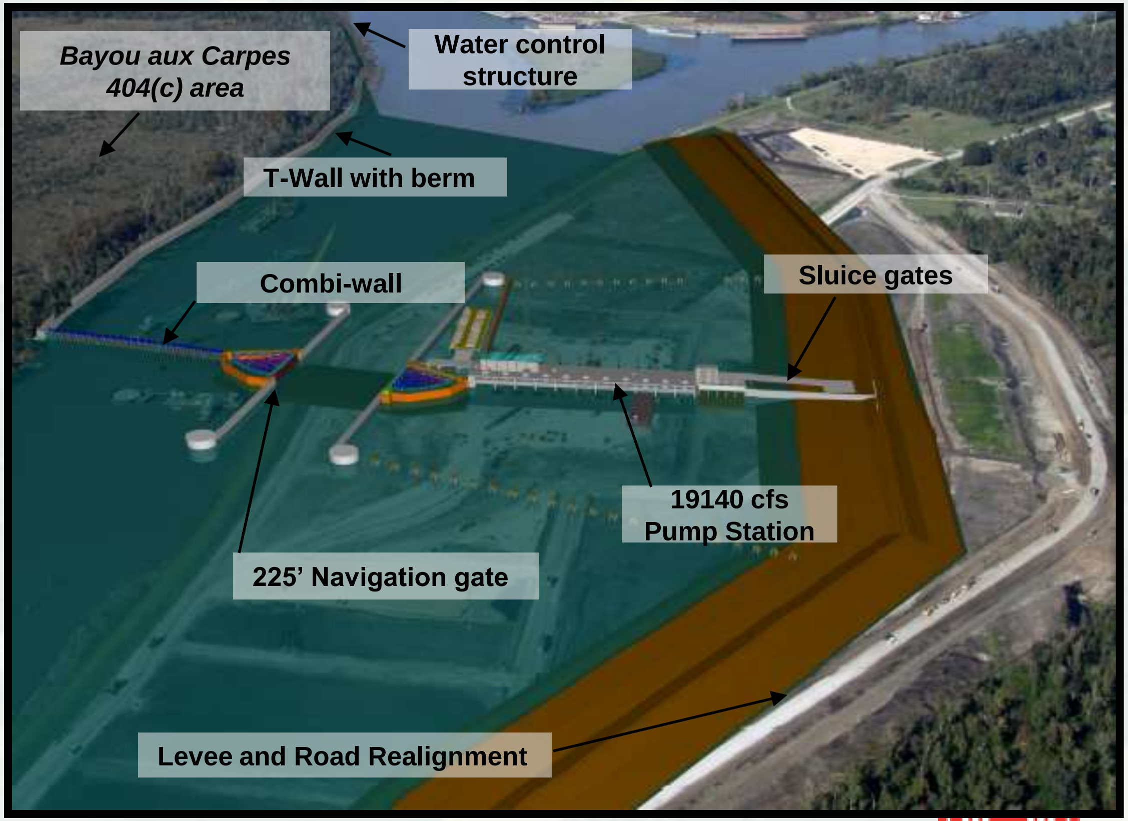
- 160 miles of piles- approx. 20 miles more than from Cleveland to Columbus
- The weight of 8 Eiffel Towers of Steel
- Enough Concrete to fill a football field 94 feet deep

GIWW –Western Closure Complex (WCC)

GIWW - West Closure Complex

Project Features:

- 19,140 cfs Drainage Pumping Station (11 x 1740 cfs vertical “Flower Pot” pumps)
- 225-foot primary navigation gate
- Sluice gates (5 – 16’ x 16’)
- T-wall along edge of Bayou aux Carpes CWA 404(c) wetlands (4200’ X 100’ construction corridor)
- Water Control Structure
- Levee and East Bayou Road Realignment
- Environmental Mitigation and Augmentations
- Foreshore Protection
- Algiers Canal dredging



WCC Cofferdam Piles

Dewatered Cofferdam

Dewatered Cofferdam

Pump Station Piles

Pile Load Test

Pile Load Test

Pile Load Test

Heave Test Section

WCC

Earthen Material Processing

New Levee Construction

New Levee Construction

East T-wall

East T-wall Preload

Questions?