National Defense Industrial Association
2005 Tri-Service Infrastructure Systems Conference and Exhibition
"Re-Energizing Engineering Excellence"

CHARACTERIZATION OF SOFT CLAY- A CASE STUDY AT CRANEY ISLAND

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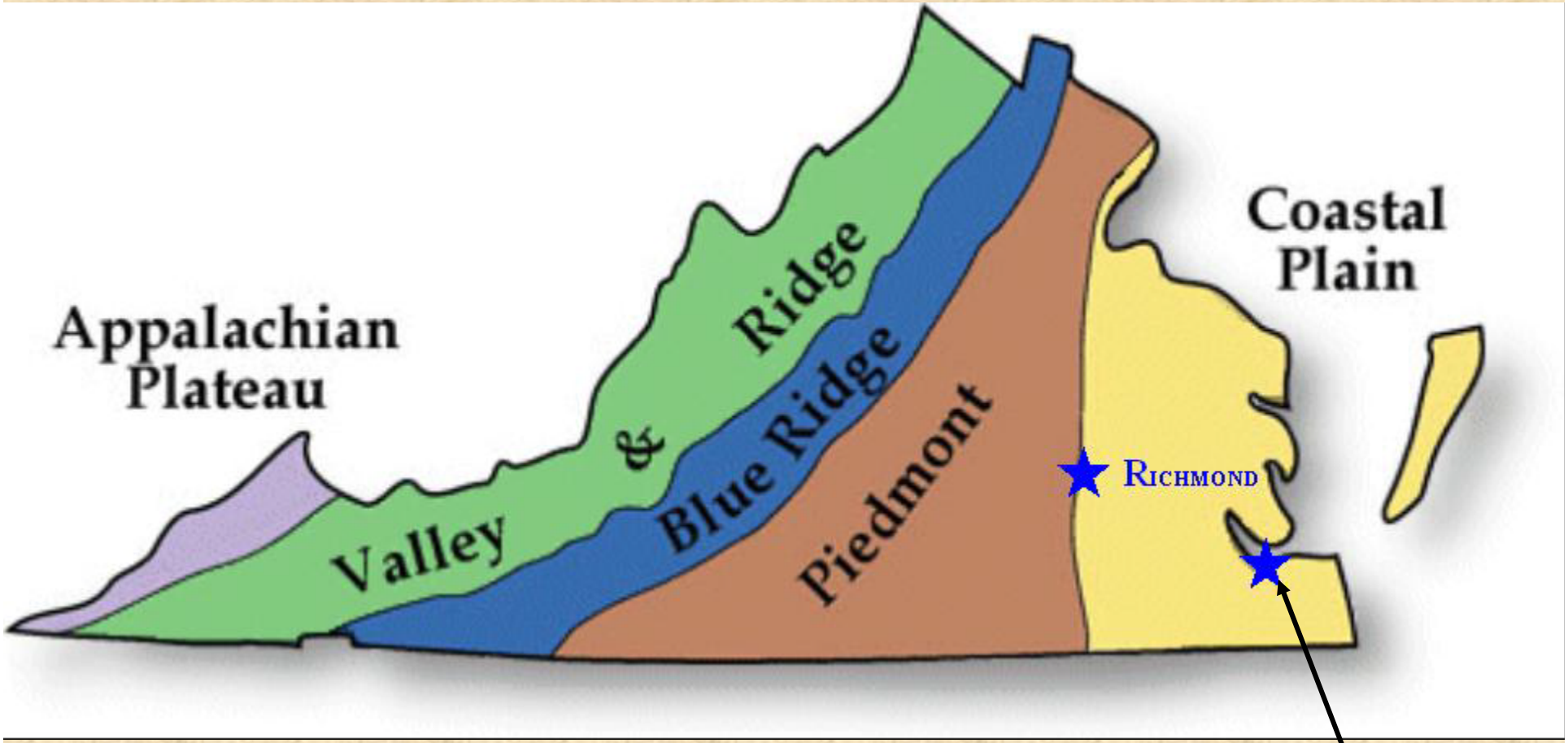
THIS MADE POSSIBLE BY:

- USACE - NORFOLK DISTRICT
  - MATTHEW BYRNE, IRA BROTMAN, DAVID PEZZA, CHERYL FROMME (ALL P.E.s)
    - PROJECT OWNER (COORDINATED FUNDING)
    - PROJECT DEVELOPMENT
- VIRGINIA GEOTECHNICAL SERVICES, P.C.
  - ENTIRE GEOTECHNICAL GROUP (AND A FEW OTHERS)
    - EXECUTION OF SCOPED SERVICES
- DR. J. MICHAEL DUNCAN, P.E.
    - SENIOR TECHNICAL CONSULTANT FOR CHARACTERIZING SOFT SOILS (CHARACTERIZATION TECHNIQUES, INTERPRETATION OF DATA, CONCEPTUAL APPLICATIONS OF ENGINEERING TECHNOLOGY).
- SUBCONSULTANTS
  - FUGRO GEOSCIENCES (SPT/FVS/CPT)
  - INSITU SOIL TESTING, INC. (DMT)
  - GLENN & SADLER (EXPLORATION LOCATIONS/SURVEY)
  - OCEAN SURVEYS, INC. (GEOPHYSICAL SURVEY)
  - COORDINATION WITH NUMEROUS OTHERS

PRESENTATION GUIDE

- INTRODUCTION
  - WHERE IS CRANEY ISLAND?
  - WHAT IS CRANEY ISLAND?
  - PROJECT INFORMATION
- APPROACH TO SUBSURFACE CHARACTERIZATION
  - RESEARCH
  - FIELD EXPLORATIONS
  - LABORATORY TESTING
- RESULTS
  - INTERPRETATION
  - APPLICATIONS
- CONCLUSIONS
- SUMMARY

WHERE IS THIS FACILITY?

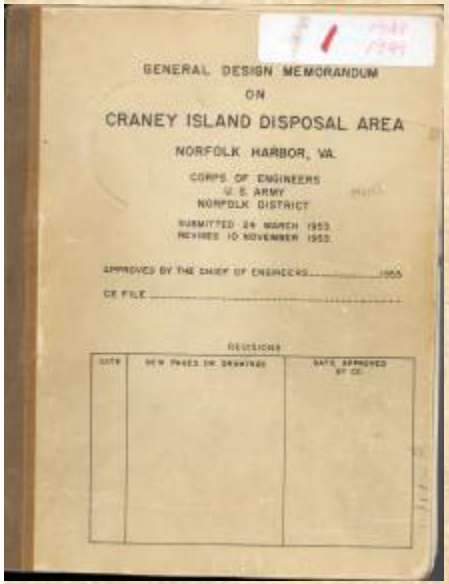


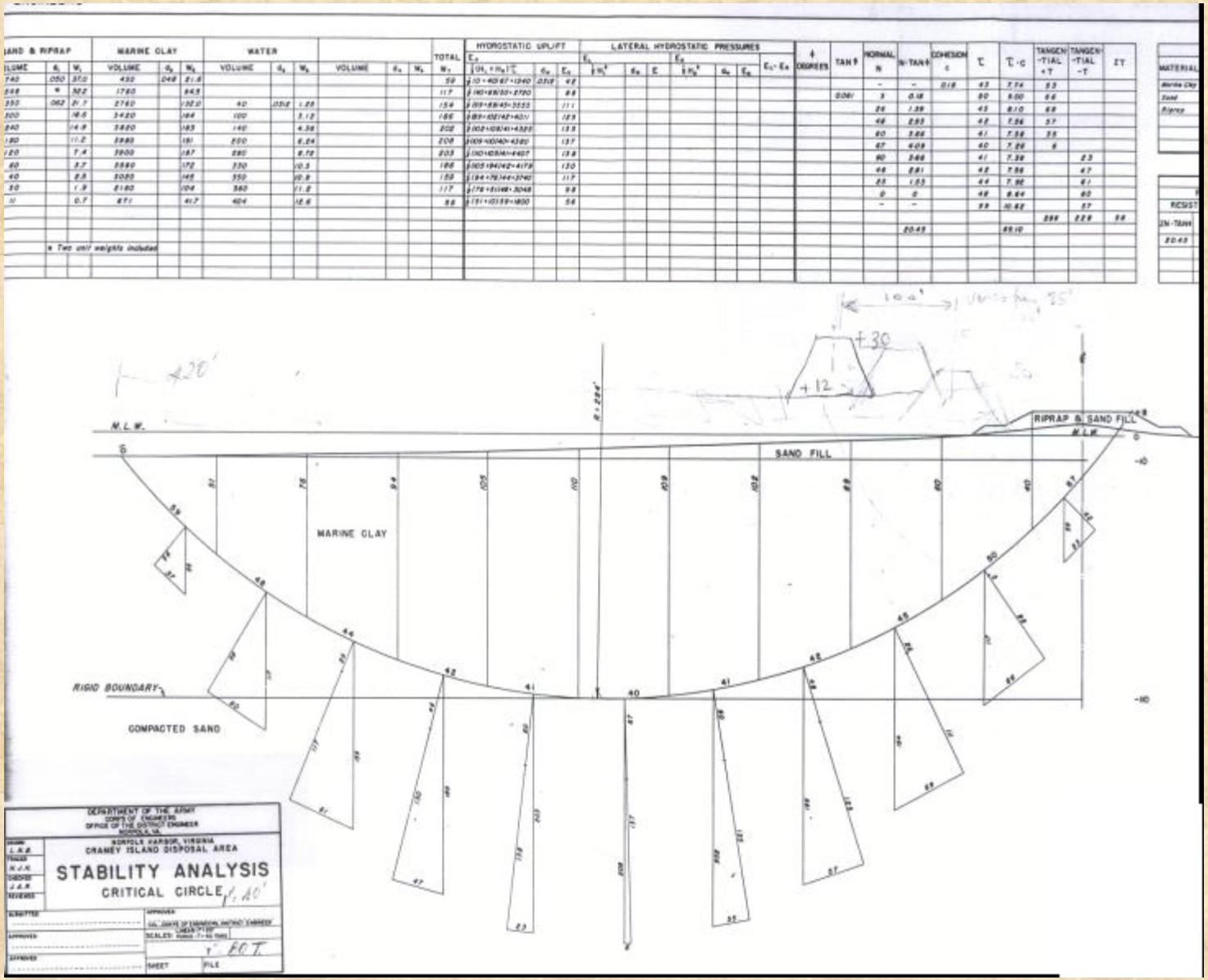
USACE DREDGE MANAGEMENT AREA - CRANEY ISLAND

WHAT IS CRANEY ISLAND?

- 2,500 ACRE DREDGE MANAGEMENT FACILITY
- CONSTRUCTION BEGAN IN AUGUST 1954
- COMPLETED IN JANUARY 1957
- MUDLINE AT EL. -10 (MLLW), BERMS EL. 8
- TODAY TOP OF FILL APPROXIMATELY EL. 40

1953 GENERAL DESIGN MEMORANDUM


GENERAL DESIGN MEMORANDUM
ON
CRANEY ISLAND DISPOSAL AREA
NORFOLK HARBOR, VA.
CORPS OF ENGINEERS
U. S. ARMY
NORFOLK DISTRICT
SUBMITTED 24 MARCH 1953
REVISED 10 NOVEMBER 1953
APPROVED BY THE CHIEF OF ENGINEERS _____ 1953
OR FILE _____
REVISIONS
DATE | NEW PAGES OR DRAWINGS | DATE APPROVED BY CE



TODAY

SEPTEMBER 28, 1954

DEPARTMENT OF THE ARMY | CORPS OF ENGINEERS | NORFOLK DISTRICT
Island Disposal Area | 28 September 1954 | Serial No. 17182
ction of West Dike | Contract No. DA-44-110-eng-3116 28 June
view of West Dike. | Contractor : Norfolk Dredging Company
Funds Civil - Construction General

DEPARTMENT OF THE ARMY | CORPS OF ENGINEERS | NORFOLK DISTRICT
y Island Disposal Area | 28 September 1954 | Serial No. 17176
ruction of West Levee | Contract No. DA-44-110-eng-3116 28 June
l view of West Levee, showing | Contractor: Norfolk Dredging Company
ave. | Funds Civil - Construction General

PROJECT SCOPE

- TEAM WITH USACE TO COMPLETE CRANEY ISLAND EASTWARD EXPANSION FEASIBILITY STUDY (2000)
  - PREPARATION OF WORK PLAN TO COMPLETE FEASIBILITY STUDY
  - EXECUTION OF SUBSURFACE EXPLORATION PROGRAM
  - COMPLETION OF LABORATORY TESTING PROGRAM
  - CHARACTERIZATION OF SUBSURFACE CONDITIONS
  - IDENTIFICATION OF APPLICABLE GROUND MODIFICATION TECHNOLOGIES AND CONSTRUCTION TECHNIQUES TO FACILITATE EXPANSION

PROJECT CONSTRAINTS

- EASTWARD EXPANSION OF DREDGE MANAGEMENT FACILITY TO INCREASE PLACEMENT AREA WITH A VERTICAL CONTAINMENT FACE.
- SHORT CONSTRUCTION PERIOD
- TOTAL POST CONSTRUCTION SETTLEMENT < 2”
  - ELASTIC
  - CONSOLIDATION
  - SECONDARY

PROJECT APPROACH

- DEVELOP GEOTECHNICAL ENGINEERING QUESTIONS
  - CAN EMBANKMENT CONSTRUCTION BE ACCOMPLISHED?
  - CAN CONSOLIDATION OCCUR QUICKLY ENOUGH?
  - CAN TOTAL SETTLEMENTS LESS THAN 2” THROUGHOUT LIFE OF THE FACILITY (SECONDARY SETTLEMENT) BE ACHIEVED?
- IDENTIFY INFORMATION TO HELP ANSWER QUESTIONS
  - SHEAR STRENGTH PROFILE
  - CONSOLIDATION PARAMETERS
  - SECONDARY COMPRESSION CHARACTERISTICS
- WHAT CALCULATIONS DOES THE DATA SUPPORT?
  - STABILITY
  - MAGNITUDE AND TIME RATE OF SETTLEMENT
  - SECONDARY COMPRESSION

PROJECT TASKS

- RESEARCH: WHAT HAS BEEN DONE?
  - PREVIOUS STUDIES
  - ANTICIPATED GEOLOGY
- FIELD EXPLORATIONS: WHAT ARE OUR CONDITIONS?
  - SHEAR STRENGTH PROFILE
  - CONSOLIDATION PARAMETERS
  - SECONDARY COMPRESSION CHARACTERISTICS
- LABORATORY TESTING: THE “REAL” ANSWER?
  - SHEAR STRENGTH (UNDRAINED AND DRAINED)
  - SETTLEMENT (PRIMARY AND SECONDARY)
  - BASIC AND INDEX SOIL PROPERTIES
- HOW DOES IT ALL FIT TOGETHER?

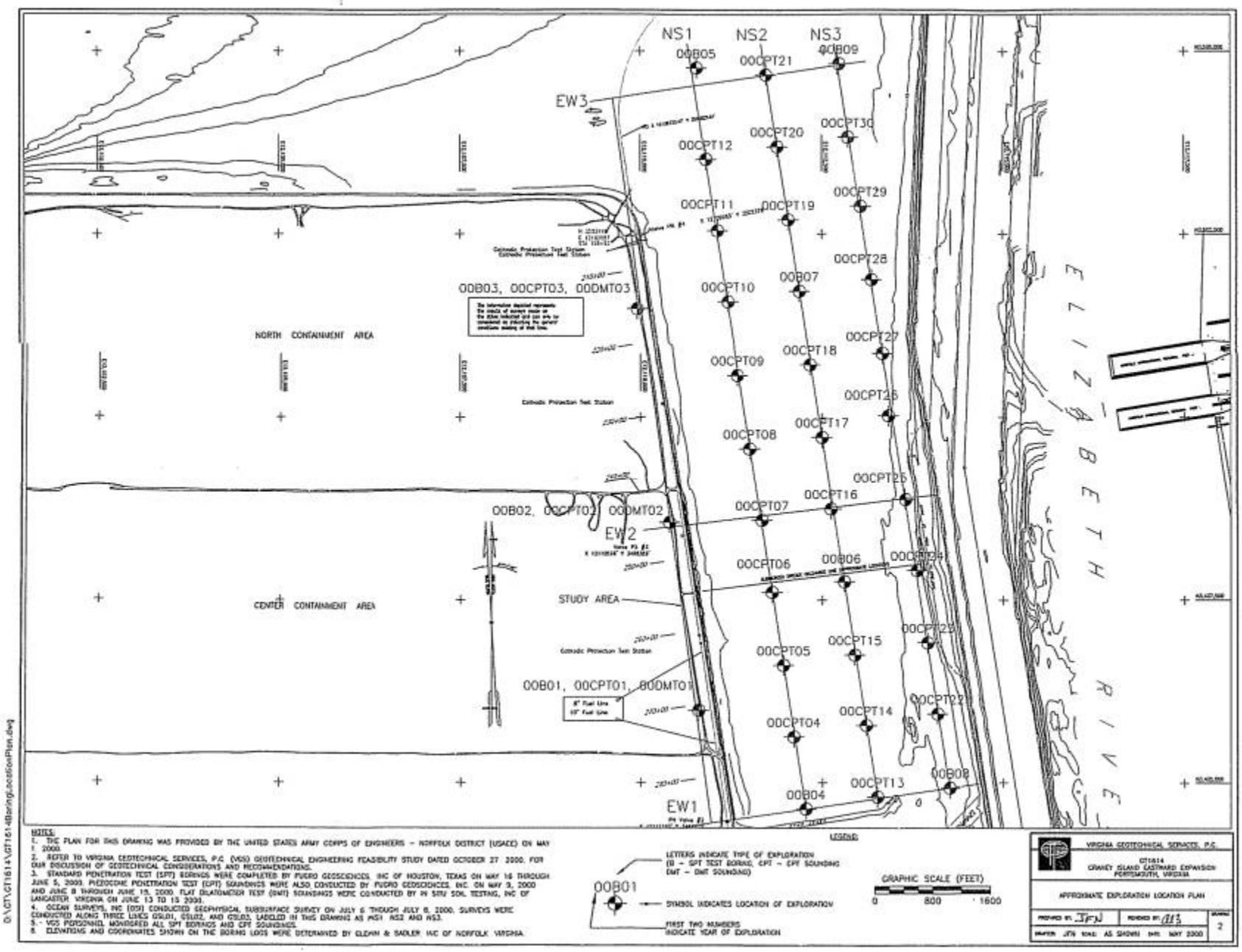
FIELD EXPLORATIONS - GOALS

- STRATIGRAPHY
  - SOFT MARINE SEDIMENTS
  - TRANSITION ZONE
  - MEDIUM DENSE SANDS OF THE YORKTOWN FORMATION
- SAMPLE COLLECTION
  - LIMIT DISTURBANCE
- COLLECT DATA OVERWATER AND OVERLAND

FIELD EXPLORATIONS - TOOLS

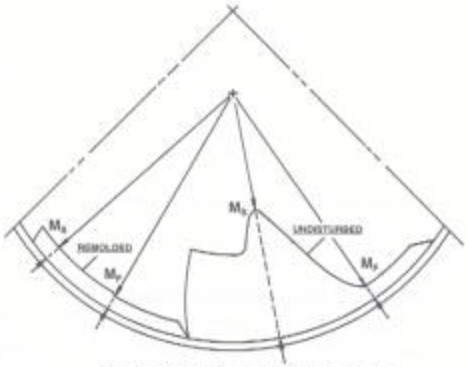
- STRATIGRAPHY
  - SPT BORINGS - SAMPLE EVERY 120”
  - DMT SOUNDINGS - SAMPLE EVERY 8”
  - CPT SOUNDINGS - SAMPLE EVERY 0.75”
- SAMPLE COLLECTION
  - SPLIT SPOON SAMPLER
  - PUSHED LINER SAMPLER
  - 5” PISTON TUBE SAMPLER
- IN SITU DATA
  - SPT - BASIC AND INDEX PROPERTIES
  - FVS - MOBILIZED UNDRAINED SHEAR STRENGTH
  - CPT - CORRELATION TO UNDRAINED SHEAR STRENGTH
  - DMT - DRAINED FRICTION ANGLE IN SANDS

EXPLORATION PLAN



FIELD EQUIPMENT

VANE AND SLIP COUPLING



RECORDING OF VANE BORING CURVE

SPT SUMMARY

- OVERLAND SPT
  - 380 FEET OF DRILLING AT THREE LOCATIONS
  - 11 FIVE-INCH DIAMETER PISTON TUBES
  - NO FVS TESTS
  - 5 DAYS
- OVERWATER SPT
  - 710 FEET OF DRILLING AT SIX LOCATIONS
  - 23 FIVE-INCH DIAMETER TUBES
  - 23 FVS TESTS
  - 13 DAYS DRILLING, 3 DAYS LOST TO WEATHER (16 DAYS)
- **SPT PRODUCTION RATE (SAMPLING EVERY 10')**
  - **OVERLAND = 75 FEET PER DAY**
  - **OVERWATER = 45 FEET PER DAY**

CPT AND DMT SUMMARY

- OVERLAND DMT (SAMPLING EVERY 8")
  - 370 FEET OF SOUNDING AT THREE LOCATIONS
  - 3 DAYS
  - **RATE = 125 FEET PER DAY** (65% FASTER THAN SPT)

- OVERLAND CPT (SAMPLING EVERY 0.75")
  - 402 FEET OF SOUNDING AT THREE LOCATIONS
  - 1 DAY
  - **RATE = 400 FEET PER DAY** (430% FASTER THAN SPT)

- OVERWATER CPT (SAMPLING EVERY 0.75")
  - 2,731 FEET OF SOUNDING AT 27 LOCATIONS
  - 8 DAYS
  - **RATE = 340 FEET PER DAY** (660% FASTER THAN SPT)

NO PHYSICAL SAMPLE RECOVERY

LABORATORY TESTING - GOALS

- CHARACTERIZE STRENGTH AND COMPRESSABILITY PARAMETERS
  - SOFT CLAY
  - TRANSITION ZONE
  - MEDIUM DENSE SANDS OF THE YORKTOWN FORMATION
- CONFIRM RESULTS OF FIELD TESTING
  - UNDRAINED SHEAR STRENGTH RELATIVE TO FVS
- CONFIRM QUALITY OF PREVIOUS STUDY DATA
  - GENERAL DATA TRENDS
  - UNDRAINED SHEAR STRENGTH PROFILE
  - SETTLEMENT PARAMETERS
  - EFFECTIVE STRESS PROFILE UNDER EAST BERM

SUMMARY OF LABORATORY TESTING

- BASIC AND INDEX SOIL PROPERTIES
  - MOISTURE CONTENT, LIMITS, GRADATION, ETC.
- SHEAR STRENGTH PARAMETERS
  - CU AND UU TRIAXIAL TESTING, LABORATORY VANE
- COMPRESSABILITY CHARACTERISTICS
  - 1-D CONSOLODATION

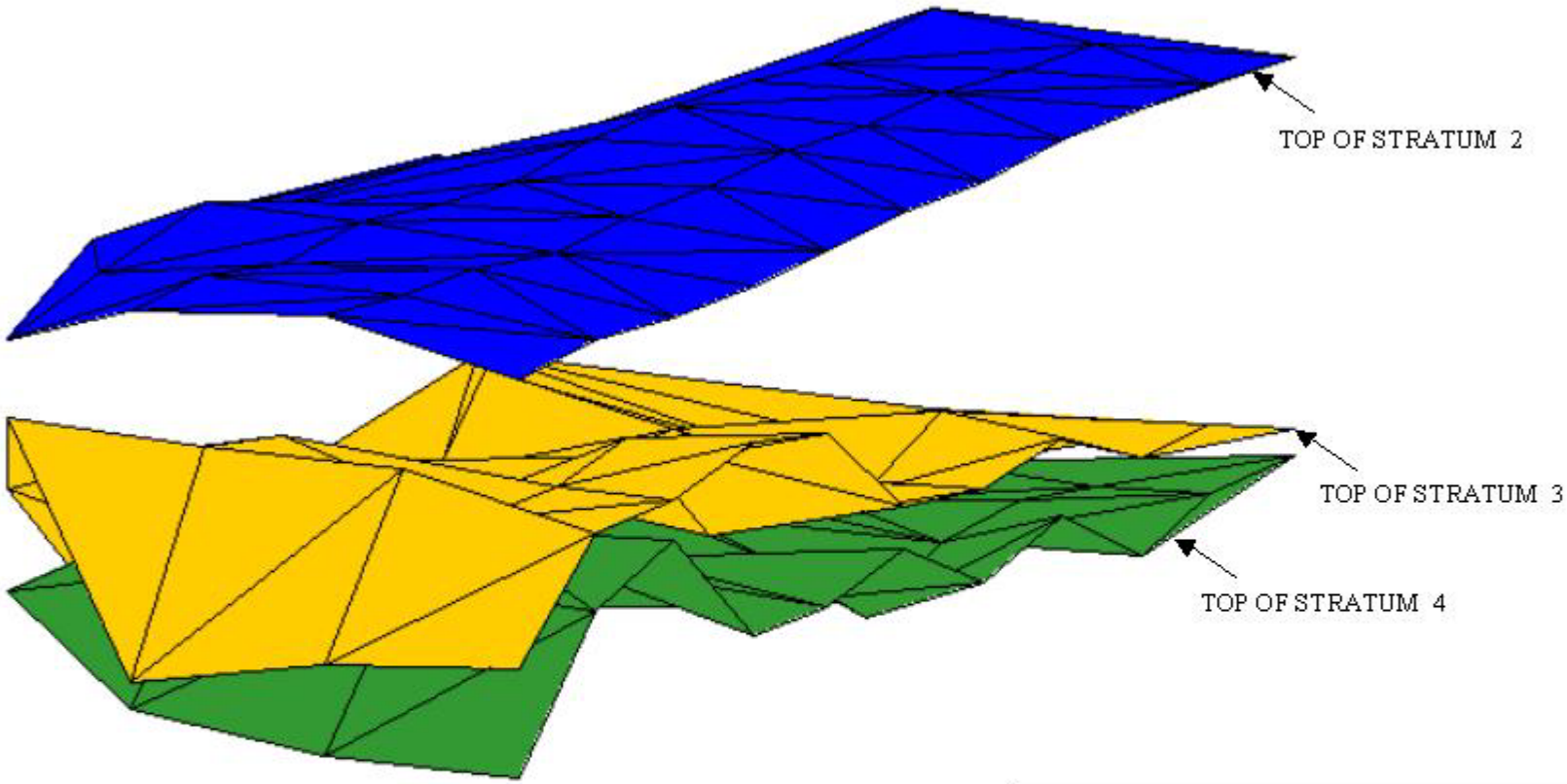
- CONCLUSIONS
  - LABORATORY TESTING PROGRAM YIELDED QUALITY DATA
  - DISTURBANCE WAS LIMITED BY COLLECTING LARGE DIAMETER SAMPLES AND TRIMMING

- LABORATORY TESTING LESSONS
  - DON'T SPEND TIME AND MONEY TESTING DISTURBED SAMPLES
  - REQUIRED LABORATORY RETRO-FIT WAS LIMITED
  - QUALITY OF TESTS ARE HIGHLY DEPENDENT ON PROCEDURES

RESULTS

- STRATIGRAPHY
  - SOFT CLAY
  - TRANSITION ZONE
  - MEDIUM DENSE SANDS OF THE YORKTOWN FORMATION
- IN SITU DATA AND LABORATORY DATA
  - UNDRAINED SHEAR STRENGTHS
  - CONSOLIDATION CHARACTERISTICS
- EFFECTIVE STRESS PROFILE (OVERLAND)
  - UNDERCONSOLIDATED
  - CPT AND LABORATORY DATA COME TOGETHER

STRATIGRAPHY: 3-D SURFACE



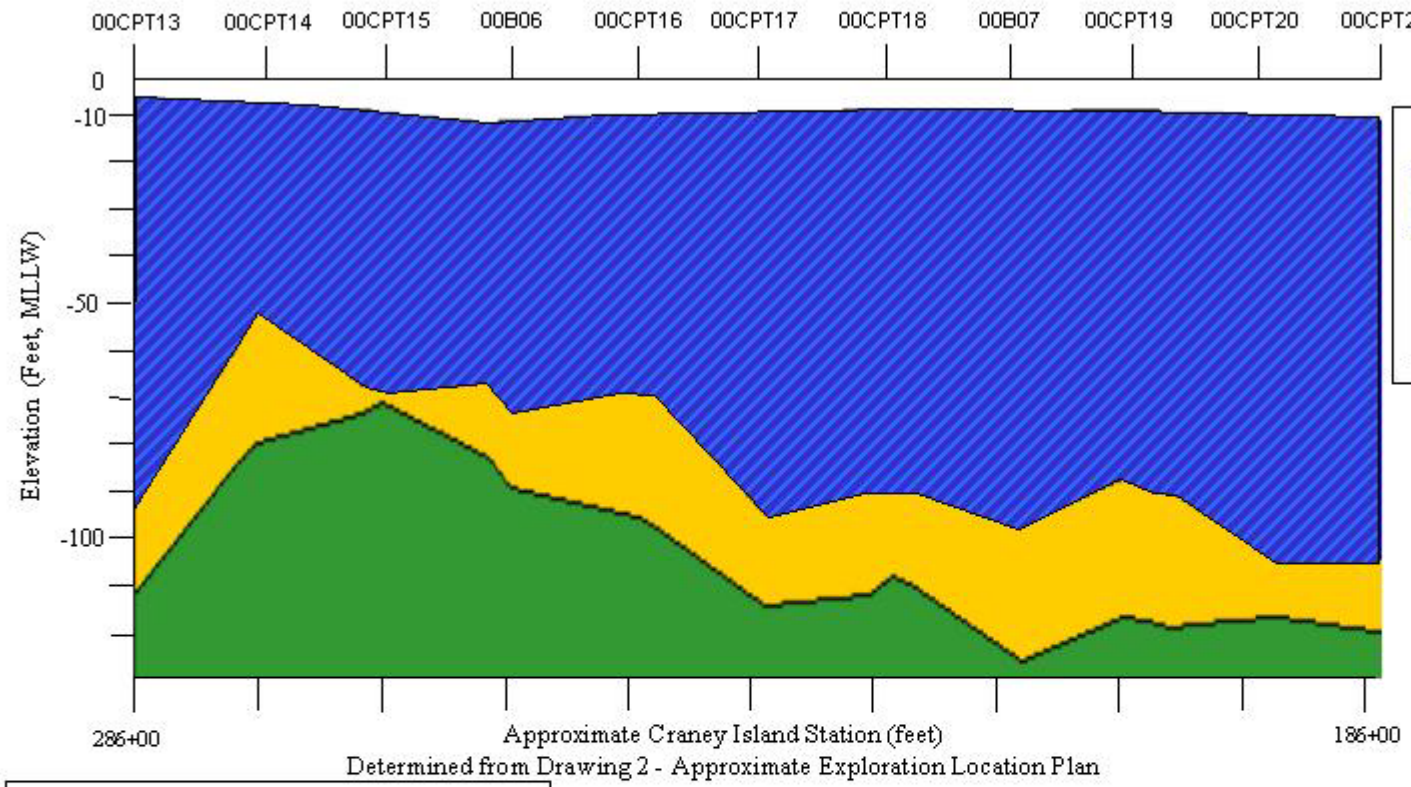
VIRGINIA GEOTECHNICAL SERVICES, P.C.

GT1614
CRANEY ISLAND EASTWARD EXPANSION
PORTSMOUTH, VIRGINIA

INTERPRETED 3-DIMENSIONAL SUBSURFACE PROFILE

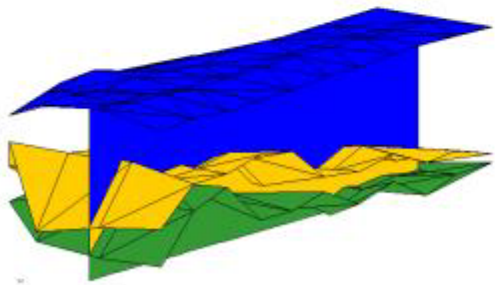
PREPARED BY:	REVIEWED BY:	Drawing
DRAFTER: ADP SCALE: As Shown DATE: Oct 2000		3

STRATIGRAPHY: NORTH-SOUTH LINE



Notes:
1. Depiction of bottom of Yorktown Formation is for graphical purposes only. Yorktown Formation was not fully penetrated during exploration for this project.

Determined from Drawing 2 - Approximate Exploration Location Plan



3-Dimensional profile of interfaces and location of cross-section

Exploration	Northing	Easting
00CPT13	3,494,802	12,113,259
00CPT14	3,495,784	12,113,108
00CPT15	3,496,747	12,112,950
00B06	3,497,749	12,112,808
00CPT16	3,498,743	12,112,623
00CPT17	3,499,724	12,112,502
00CPT18	3,500,716	12,112,338
00B07	3,501,717	12,112,190
00CPT19	3,502,690	12,112,035
00CPT20	3,503,693	12,111,885
00CPT21	3,504,680	12,111,731

Locations surveyed by Glenn & Sadler of Norfolk, Virginia

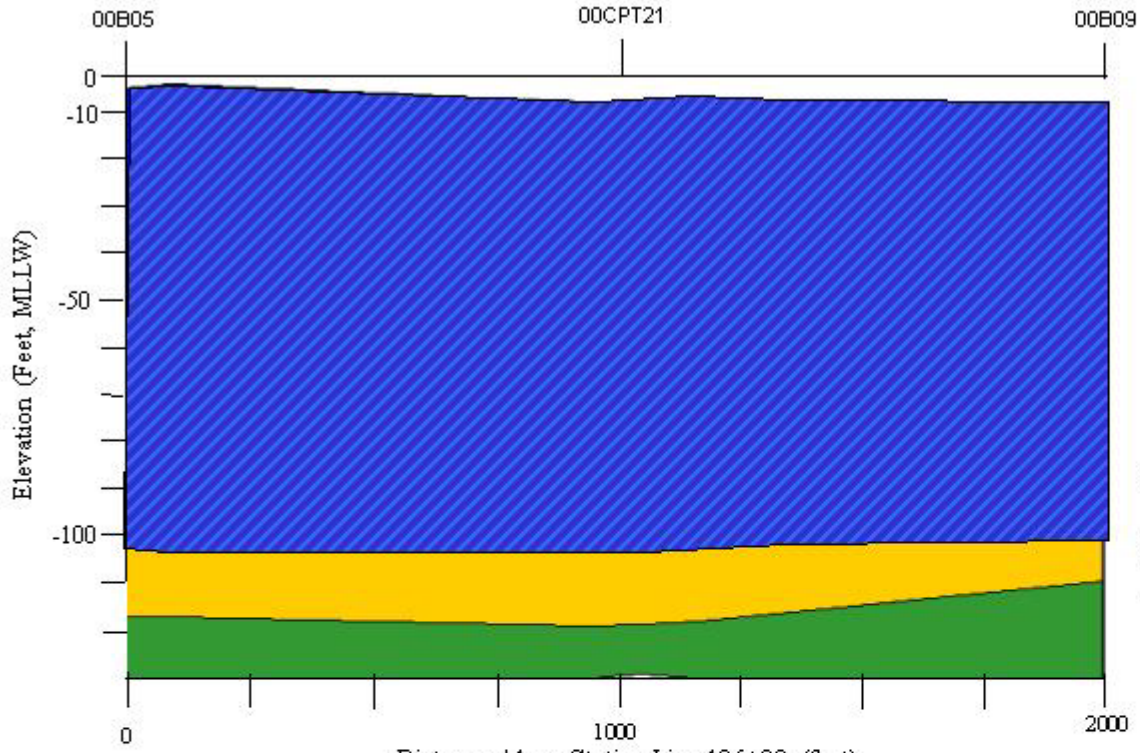
VIRGINIA GEOTECHNICAL SERVICES, P.C.

GT1614
CRANEY ISLAND EASTWARD EXPANSION
PORTSMOUTH, VIRGINIA

INTERPRETED SUBSURFACE PROFILE
ALONG NS2

PREPARED BY:	REVIEWED BY:	Drawing
DRAFTER: ADP	SCALE: As Shown DATE: Oct 2000	6

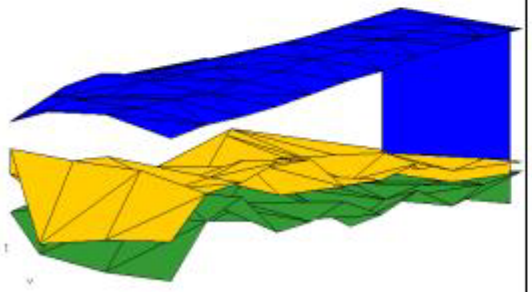
STRATIGRAPHY: EAST-WEST LINE



Legend

- Stratum 2 (Upper Norfolk Formation)
- Stratum 3 (Lower Norfolk Formation)
- Stratum 4 (Yorktown Formation)

Notes:
1. Depiction of bottom of Yorktown Formation is for graphical purposes only. Yorktown Formation was not fully penetrated during exploration for this project.



3-Dimensional profile of interfaces and location of cross-section

Exploration	Northing	Easting
00B05	3,504,767	12,110,775
00CPT21	3,504,680	12,111,731
00B09	3,504,828	12,112,742

Locations surveyed by Glenn & Sadler of Norfolk, Virginia

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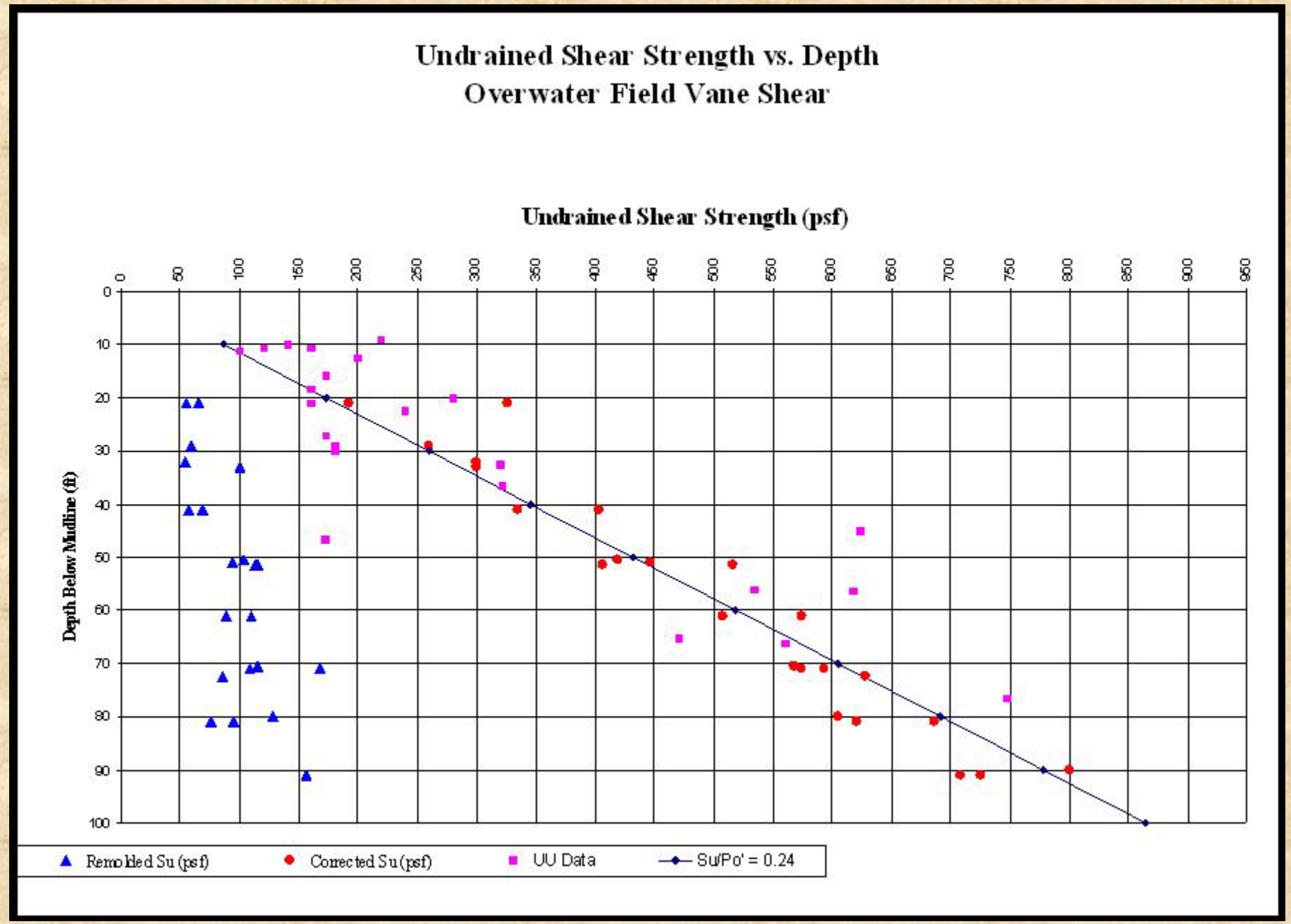
GT1614
CRANEY ISLAND EASTWARD EXPANSION
PORTSMOUTH, VIRGINIA

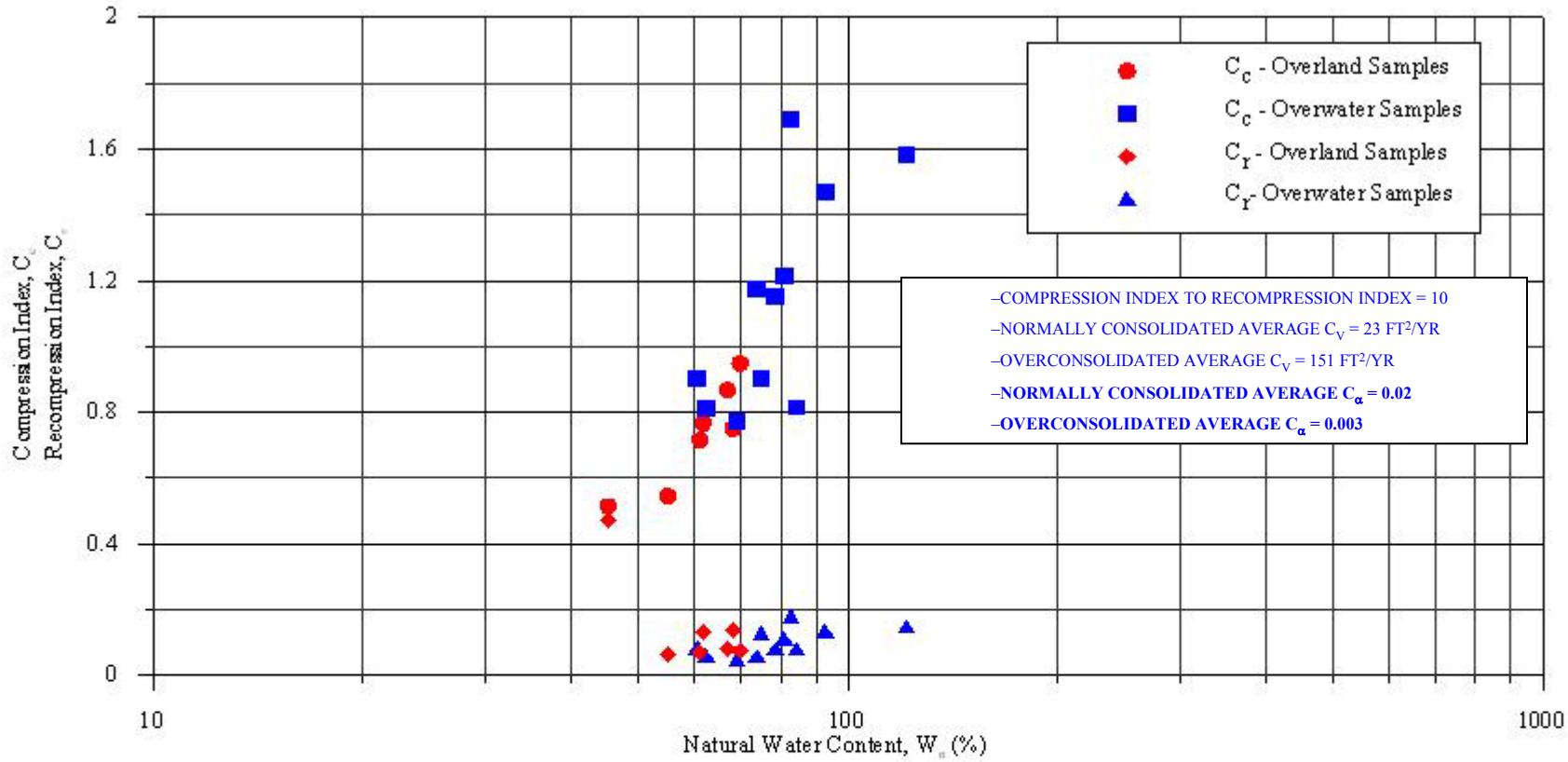
INTERPRETED SUBSURFACE PROFILE ALONG EW3

PREPARED BY:	REVIEWED BY:	Drawing
DRAFTER: ADP	SCALE: As Shown DATE: Oct 2000	10

UNDRAINED SHEAR STRENGTH TEST RESULTS



CONSOLIDATION TEST RESULTS



NOTES:
1. C_c and C_r determined from laboratory consolidation tests.
2. $C_c = (1+e_0)CR$, $C_r = (1+e_0)RR$
   where e_0 = Initial Void Ratio, CR = Compression Ratio
   and RR = Recompression Ratio

VIRGINIA GEOTECHNICAL SERVICES, P.C.

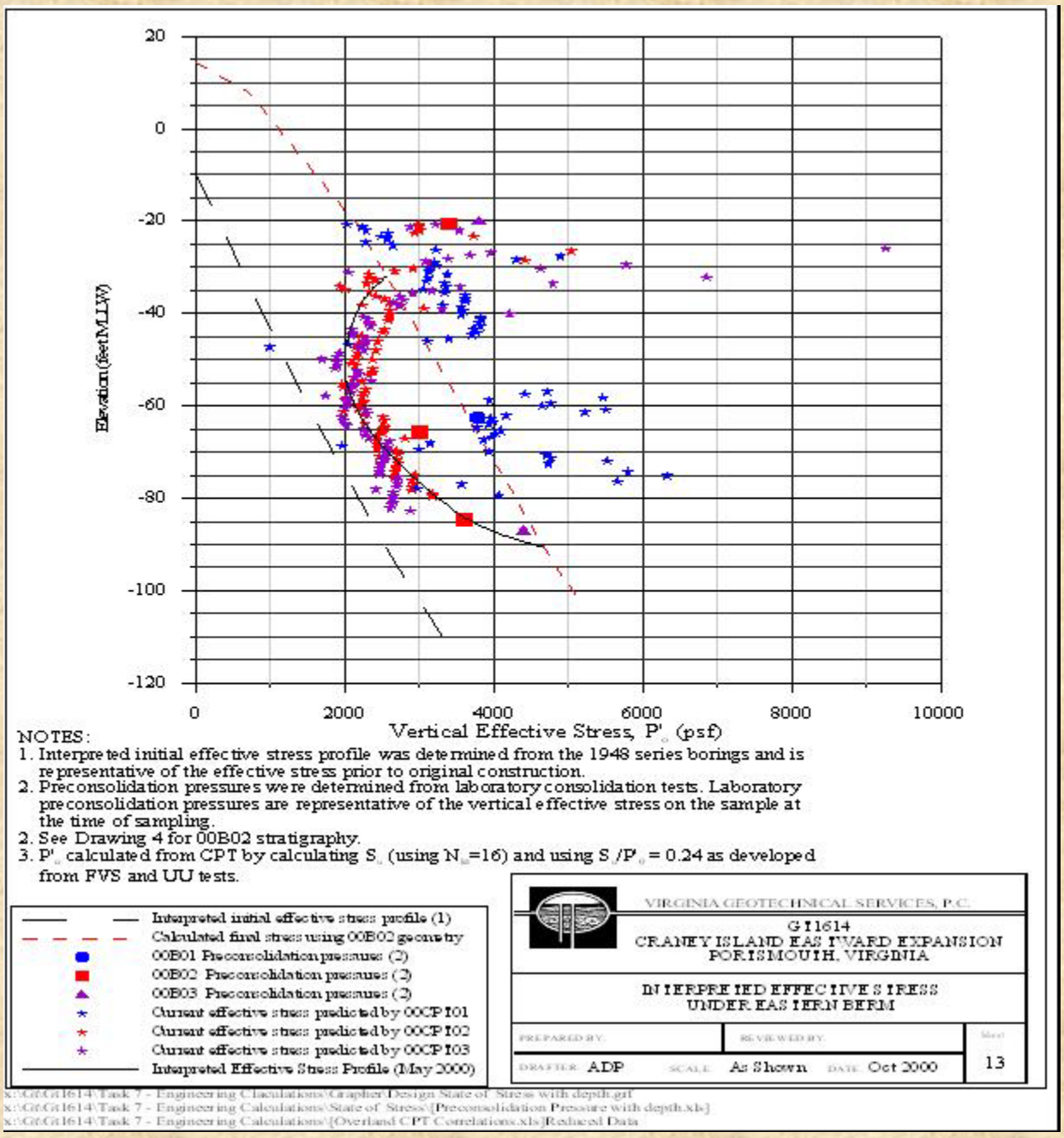
GT1614
CRANEY ISLAND EASTWARD EXPANSION
PORTSMOUTH, VIRGINIA

C_c & C_r vs. W_n

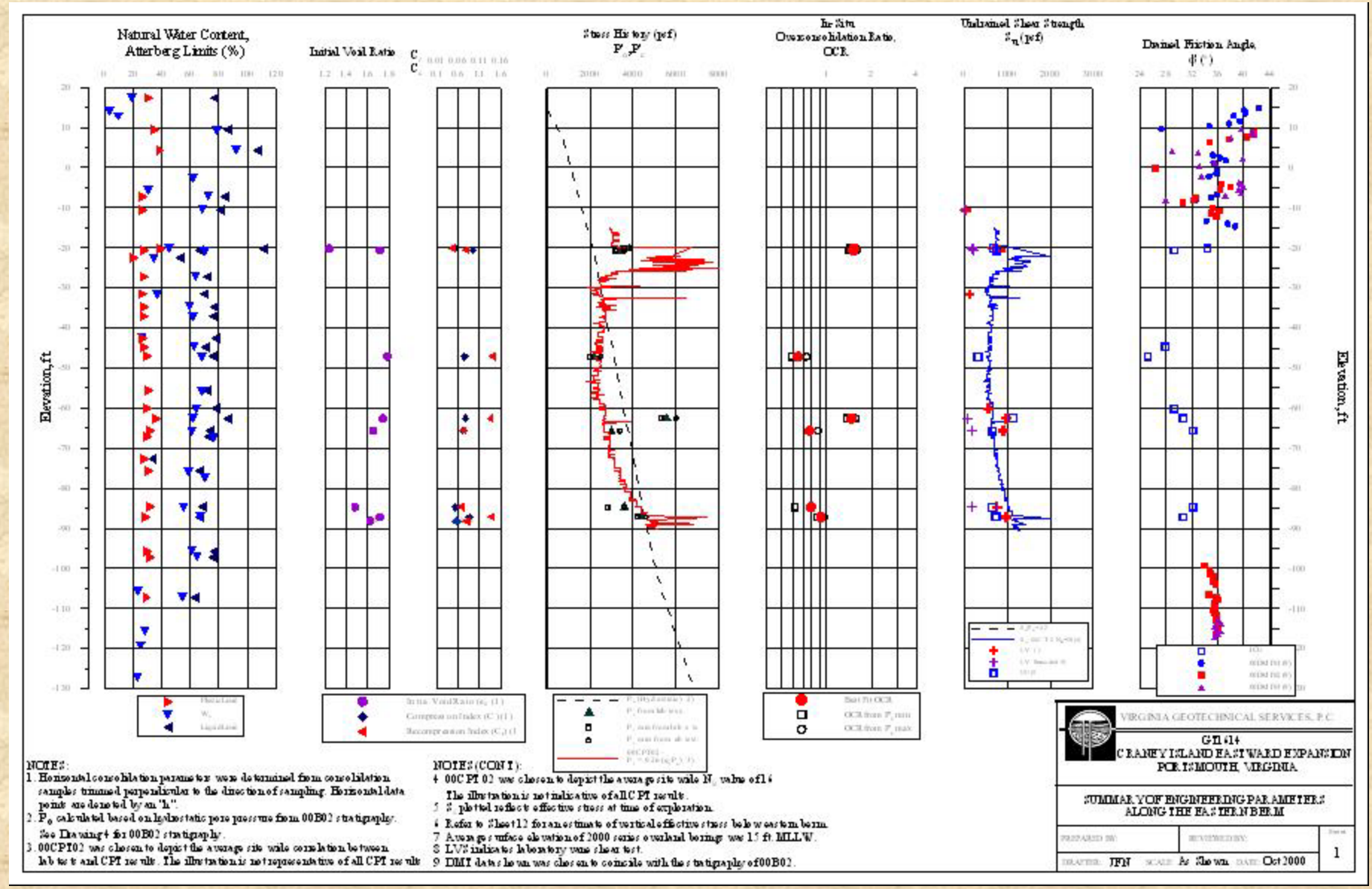
PREPARED BY:	REVIEWED BY:	Sheet
DRAFTER: JFN	SCALE: As Shown	DATE: Oct 2000	7

x:\Gt\Gt1614\Task 7 - Engineering Calculations\Grapher\Cr,Cc vs wn.grf
x:\Gt\Gt1614\Task 7 - Engineering Calculations\[Consolidation Summary.xls]Consol Summary (Overland)

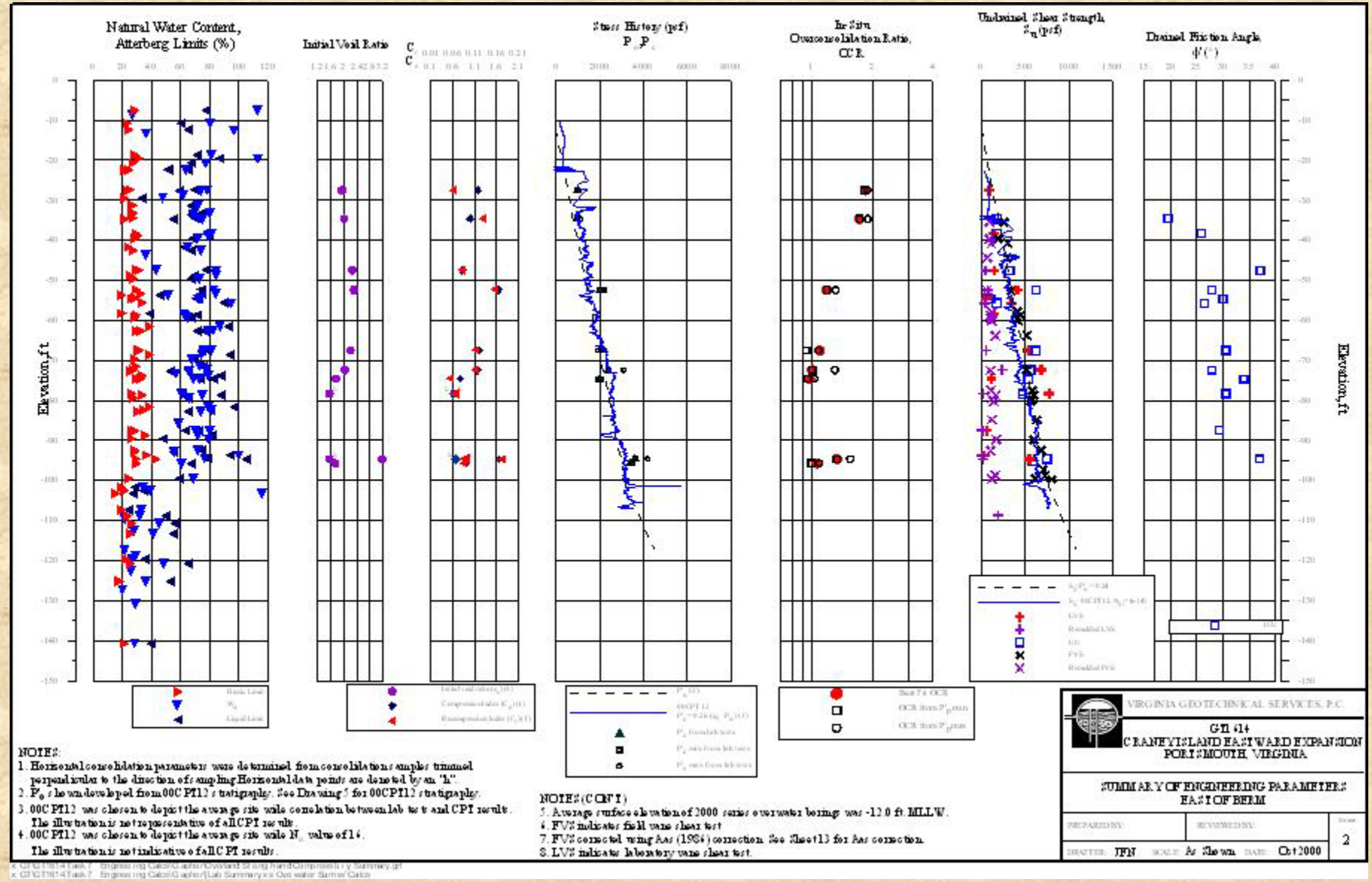
EFFECTIVE STRESS PROFILE UNDER EAST BERM



SUMMARY OF OVERLAND ENGINEERING PARAMETERS



SUMMARY OF OVERWATER ENGINEERING PARAMETERS

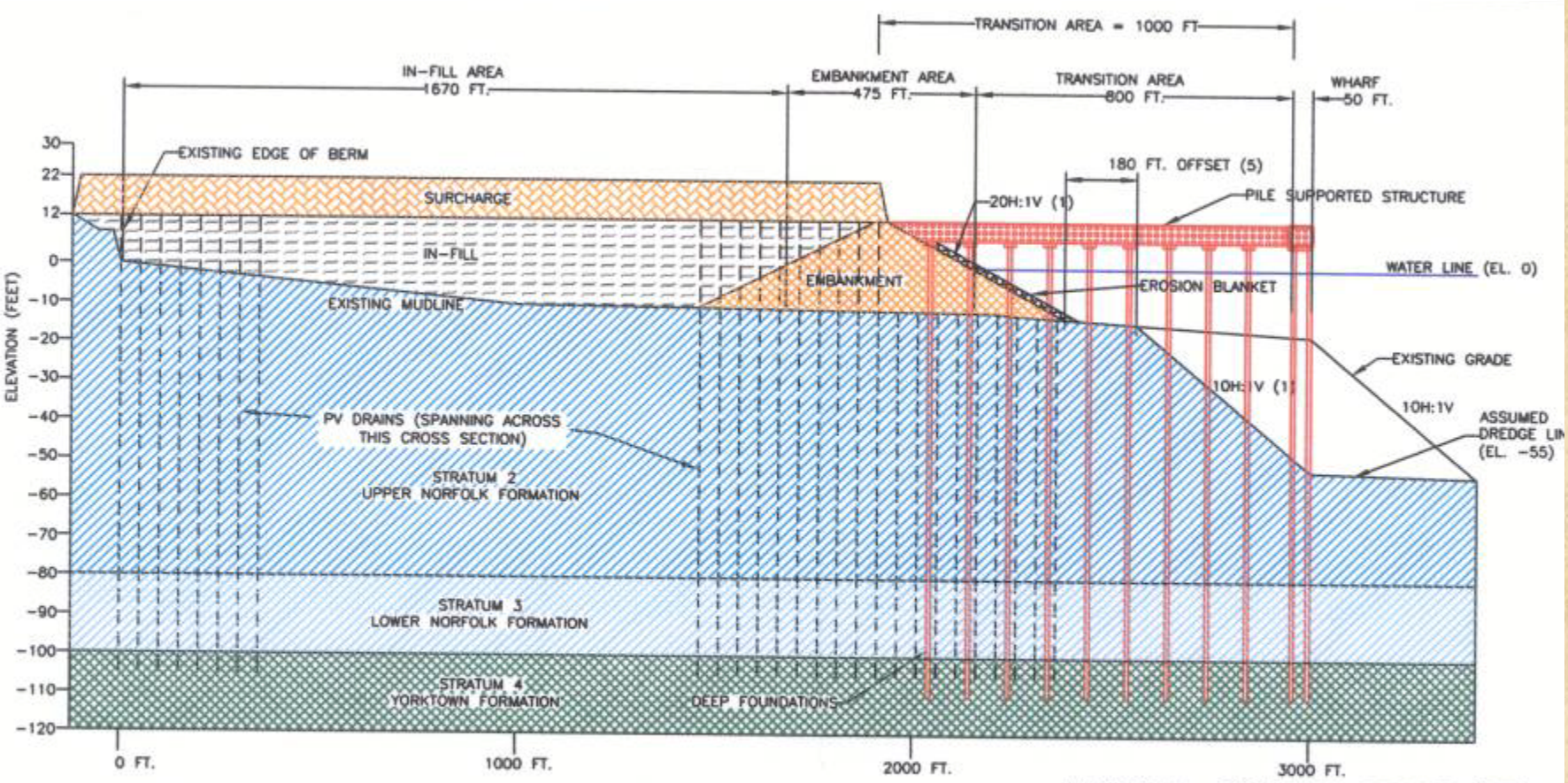


APPLICATIONS - WHAT DOES IT ALL MEAN?

- QUESTIONS
  - CAN EMBANKMENT CONSTRUCTION BE ACCOMPLISHED?
  - CAN CONSOLIDATION OCCUR QUICKLY ENOUGH?
  - CAN TOTAL SETTLEMENTS LESS THAN 2” THROUGHOUT LIFE OF THE FACILITY (SECONDARY SETTLEMENT) BE ACHIEVED?
  - CAN A BENEFICIAL CONSTRUCTION ALTERNATIVE BE ACHIEVED?

- ANSWERS
  - YES - ORIGINAL CONSTRUCTION WAS COMPLETED IN 3.5 YEARS. THE AREA OF PROPOSED EXPANSION IS FOUR TIMES SMALLER.
  - YES - WILL REQUIRE THE USE OF PV DRAINS.
  - YES - SURCHARGING CAN LIMIT POST CONSTRUCTION SETTLEMENTS TO <2”.
  - YES - PV DRAINS, GROUND IMPROVEMENT AND SURCHARGING CAN FACILITATE “RAPID” CONSTRUCTION OF ADDITIONAL DREDGE PLACEMENT AREA.

CONCEPTUAL CROSS SECTION - PROVEN



NOTES:

1) ALL SLOPES SHOWN FOR ILLUSTRATION ONLY. ACTUAL SLOPES TO BE DETERMINED DURING DESIGN PHASE.
2) PV DRAINS ARE SHOWN ON THIS DRAWING FOR ILLUSTRATIVE PURPOSES ONLY. ACTUAL PV DRAIN LOCATIONS WILL WILL EXTEND ACROSS THE ENTIRE SITE.
3) VERTICAL SCALE IS EXAGERATED TEN TIMES LARGER THAN HORIZONTAL SCALE.
4) ALL ELEVATIONS ARE REFERENCED TO MEAN LOWER LOW WATER LEVEL (MLLW).
5) OFFSET PER STABILITY CALCULATIONS COMPLETED BY FOWLER ET AL. (1987).

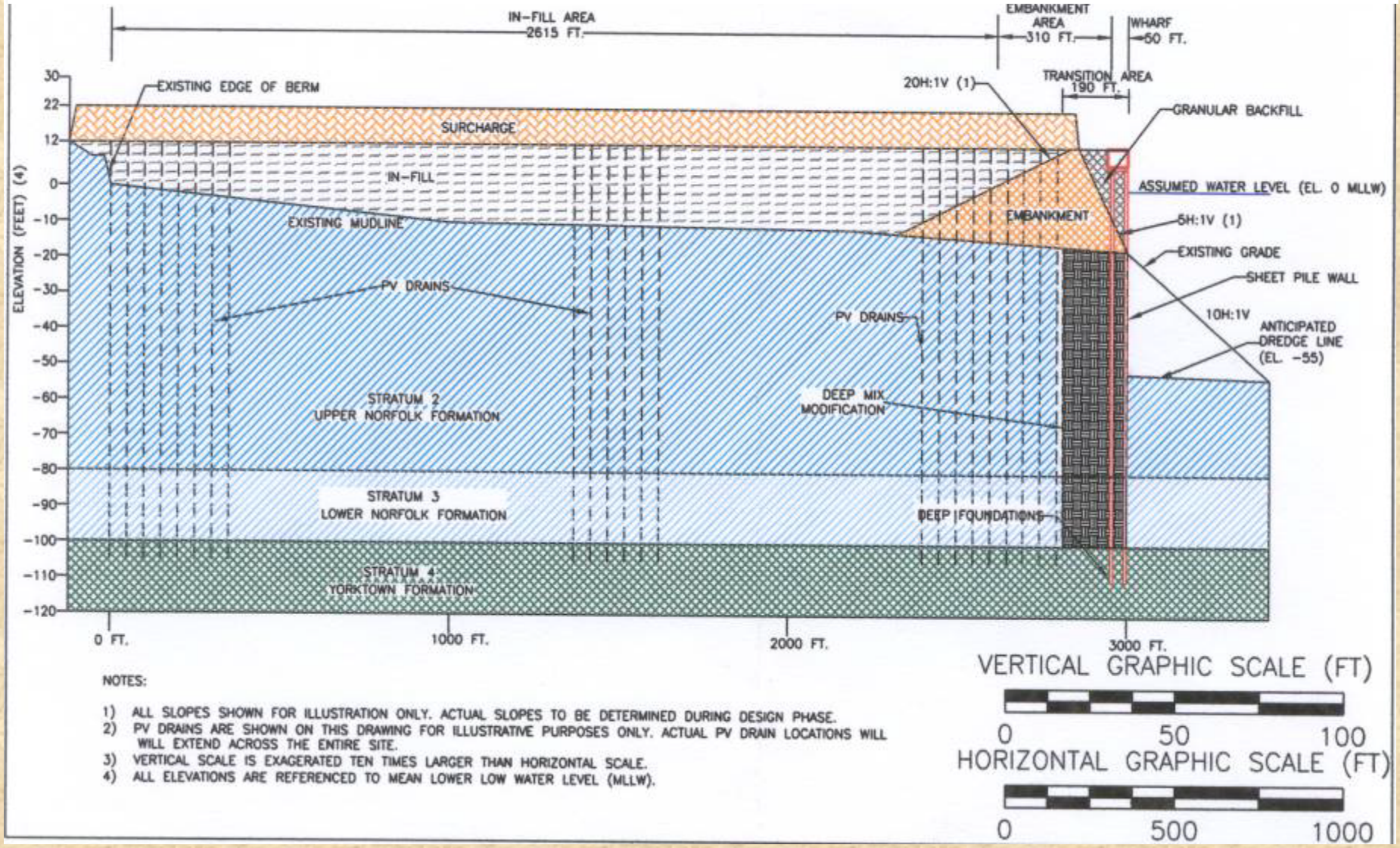
VERTICAL GRAPHIC SCALE (FT)

0 50 100

HORIZONATAL GRAPHIC SCALE (FT)

0 500 1000

CONCEPTUAL CROSS SECTION - INNOVATIVE



COMPARISON OF CONCEPTUAL SECTIONS

- PV DRAINS AND SURCHARGE
  - TOTAL ADDITIONAL MANAGEMENT VOLUME = 13.4 MILLION YD^3
  - ESIMTATED PROBABLE CONSTRUCTION COST= "X" DOLLARS
  - APPROXIMATE COST PER UNIT VOLUME ADDITIONAL MANAGEMENT SPACE = "Y" DOLLARS PER YD^3

- DEEP SOIL MIXING, PV DRAINS, AND SURCHARGE
  - TOTAL ADDITIONAL MANAGEMENT VOLUME = 21.0 MILLION YD^3
  - ESIMTATED PROBABLE CONSTRUCTION COST = 85% "X" DOLLARS
  - APPROXIMATE COST PER UNIT VOLUME ADDITIONAL MANAGEMENT SPACE = 50% "Y" DOLLARS PER YD^3

- CONCLUSION
  - AN INNOVATIVE APPROACH CAN SUBSTANTIALLY INCREASE THE AREA AVAILABLE FOR DREDGE MANAGEMENT BEYOND THAT POSSIBLE WITH TRADITIONAL CONSTRUCTION METHODS.

CONCLUSIONS

- COST OF A DETAILED SUBSURFACE INVESTIGATION PROGRAM WAS LESS THAN 1/10 OF A PERCENT OF AN ESTIMATED CONCEPTUAL COST.

- SUBSURFACE CONDITIONS IN THE VICINITY OF CRANEY ISLAND ARE FAIRLY CONSISTENT AND CAN BE CHARACTERIZED WITH CURRENT EXPLORATION TECHNIQUES.

- USE OF A JACK-UP BARGE, FULLY CASED DRILLING METHODS, AND LARGE DIAMETER SAMPLES ARE PROVEN WAYS TO LIMIT SAMPLE DISTURBANCE.

- THE CPT CAN BE AN EFFECTIVE TOOL FOR RAPIDLY CHARACTERIZING STRATIGRAPHY AND UNDRAINED SHEAR STRENGTH AT CRANEY ISLAND.

- THE CPT CAN BE AN EFFECTIVE TOOL TO DETERMINE % CONSOLIDATION UNDER FILL AREAS.

SUMMARY

- A PROJECT APPROACH CONSISTING OF RESEARCH, FIELD EXPLORATIONS, AND LABORATORY TESTING YIELDED THE DESIRED RESULTS FOR THIS STUDY.

- UTILIZATION OF MULTIPLE EXPLORATION TECHNIQUES RESULTED IN AN EFFICIENT FIELD DATA COLLECTION PROGRAM.

- HIGH QUALITY LABORATORY TESTING IMPROVED CONFIDENCE IN THE RESULTS OF THE FIELD DATA.

- THE SOIL PROPERTIES AND PARAMETERS DETERMINED BY THIS EFFORT ARE CONSISTENT WITH PREVIOUS EFFORTS.

- A BENEFICIAL EASTWARD EXPANSION COULD BE ACHIEVED BY USING AN INNOVATIVE APPROACH.

CHARACTERIZATION OF SOFT CLAY- A CASE STUDY AT CRANEY ISLAND

THANK YOU!

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