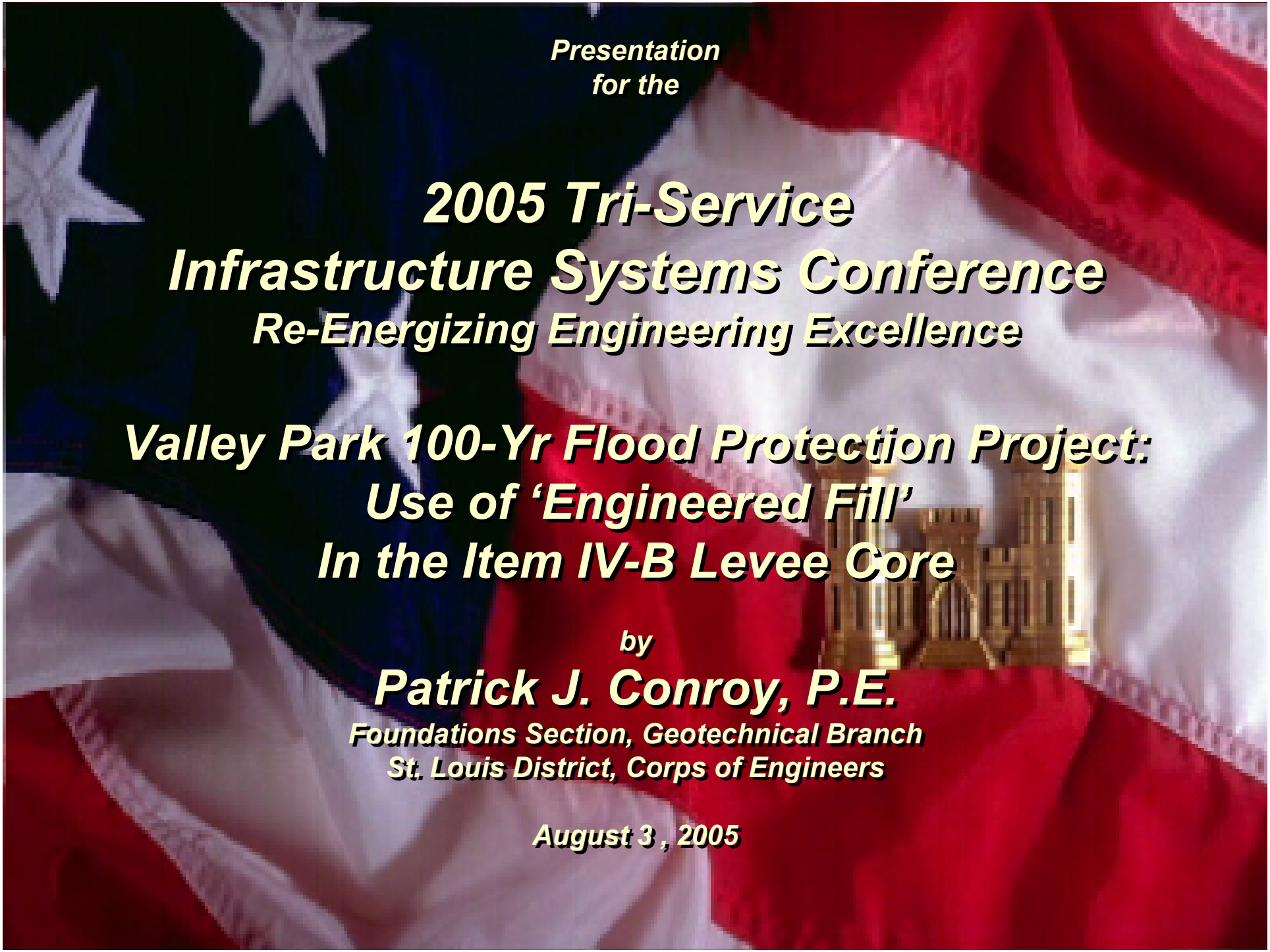


Presentation
for the

2005 Tri-Service Infrastructure Systems Conference

Re-Energizing Engineering Excellence

Valley Park 100-Yr Flood Protection Project: Use of 'Engineered Fill' In the Item IV-B Levee Core

by

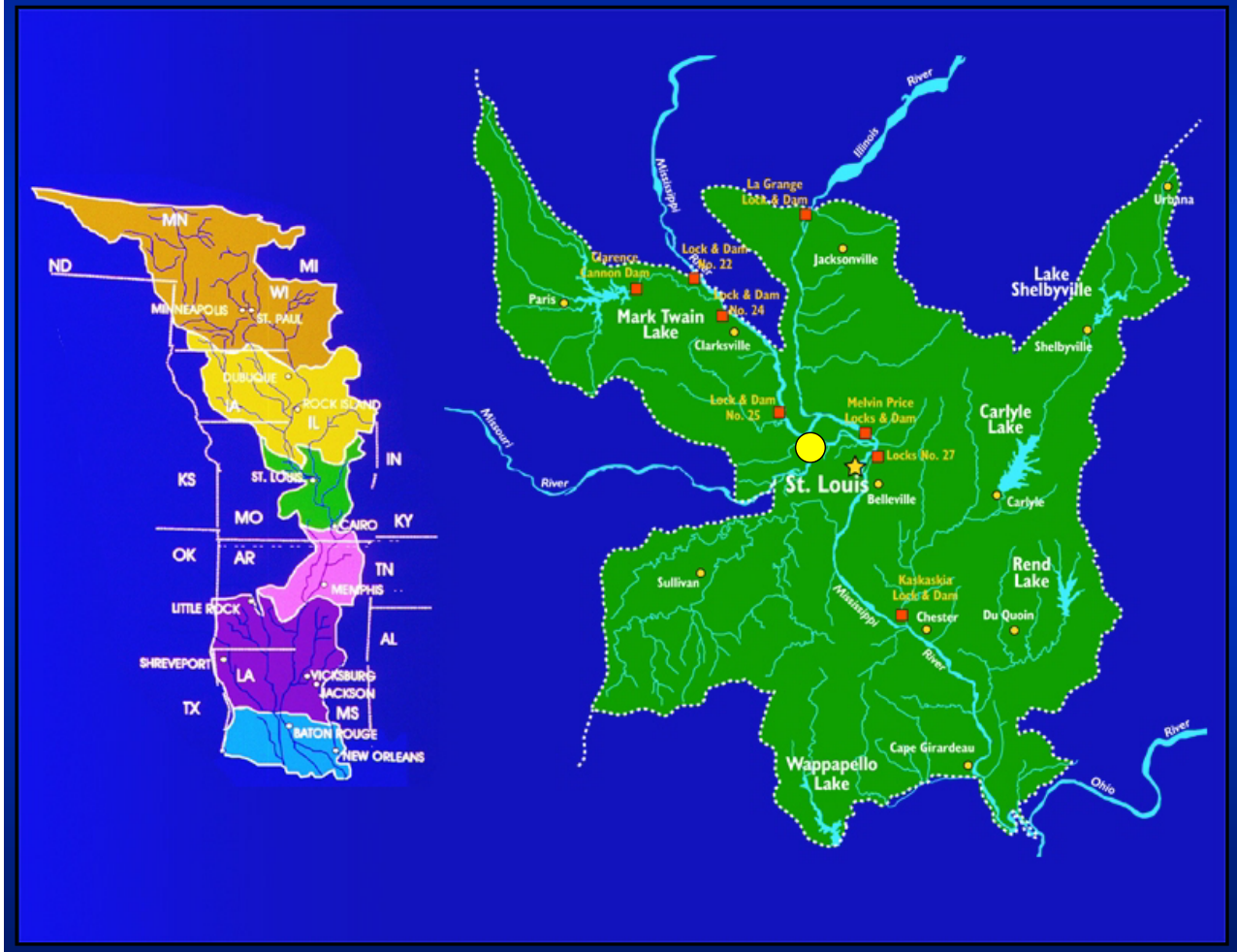
Patrick J. Conroy, P.E.

Foundations Section, Geotechnical Branch
St. Louis District, Corps of Engineers

August 3 , 2005

US Army Corps of Engineers

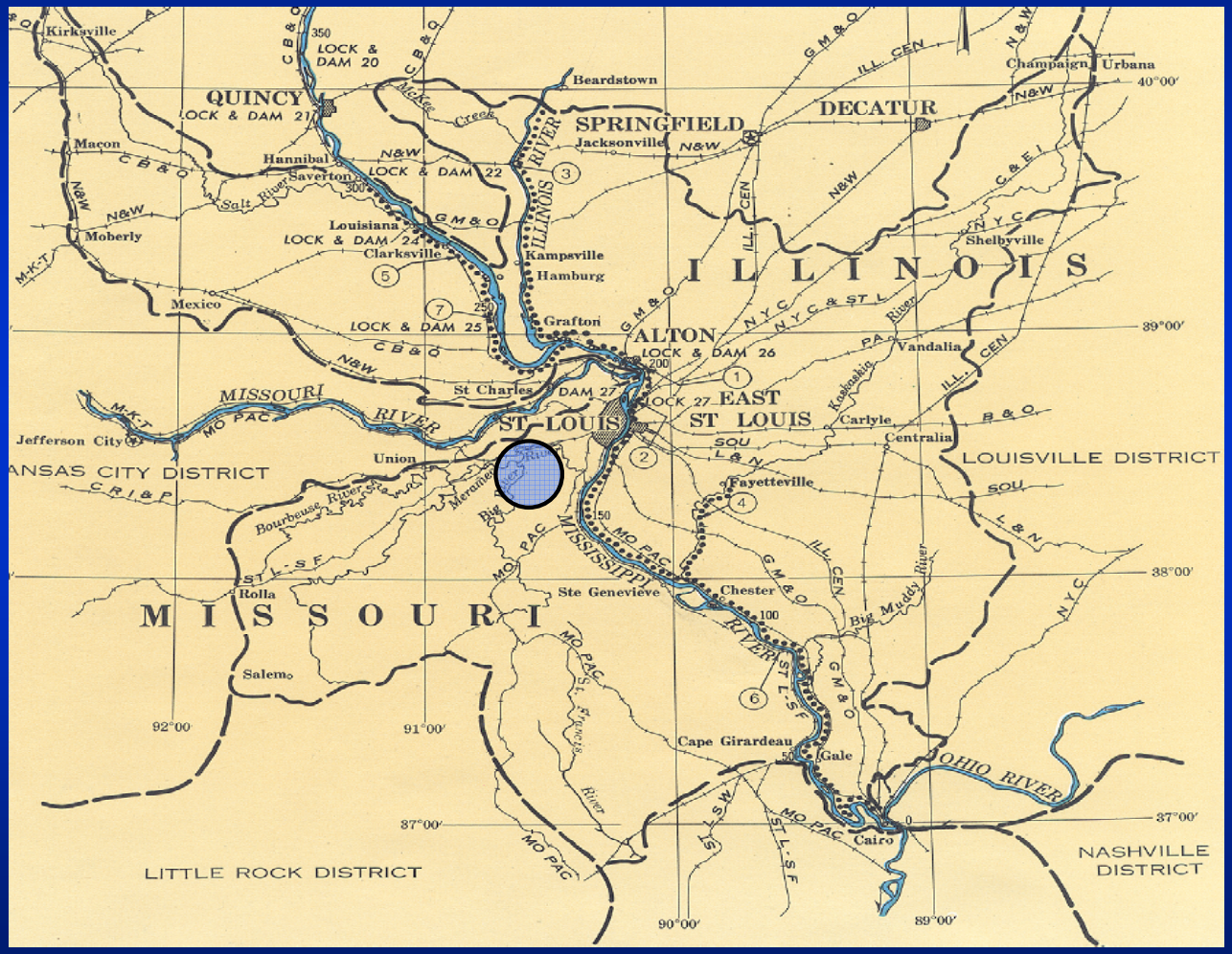
St. Louis District and Location of Valley Park Project



- 10 rivers
- 5 lock & dam sites
- 5 Corps lakes
- 720 miles of levees
- 92 flood control systems
- 416 miles of navigable channel
- 70 pumping plants
- 162 recreation areas
- 1 hydropower dam

US Army Corps of Engineers

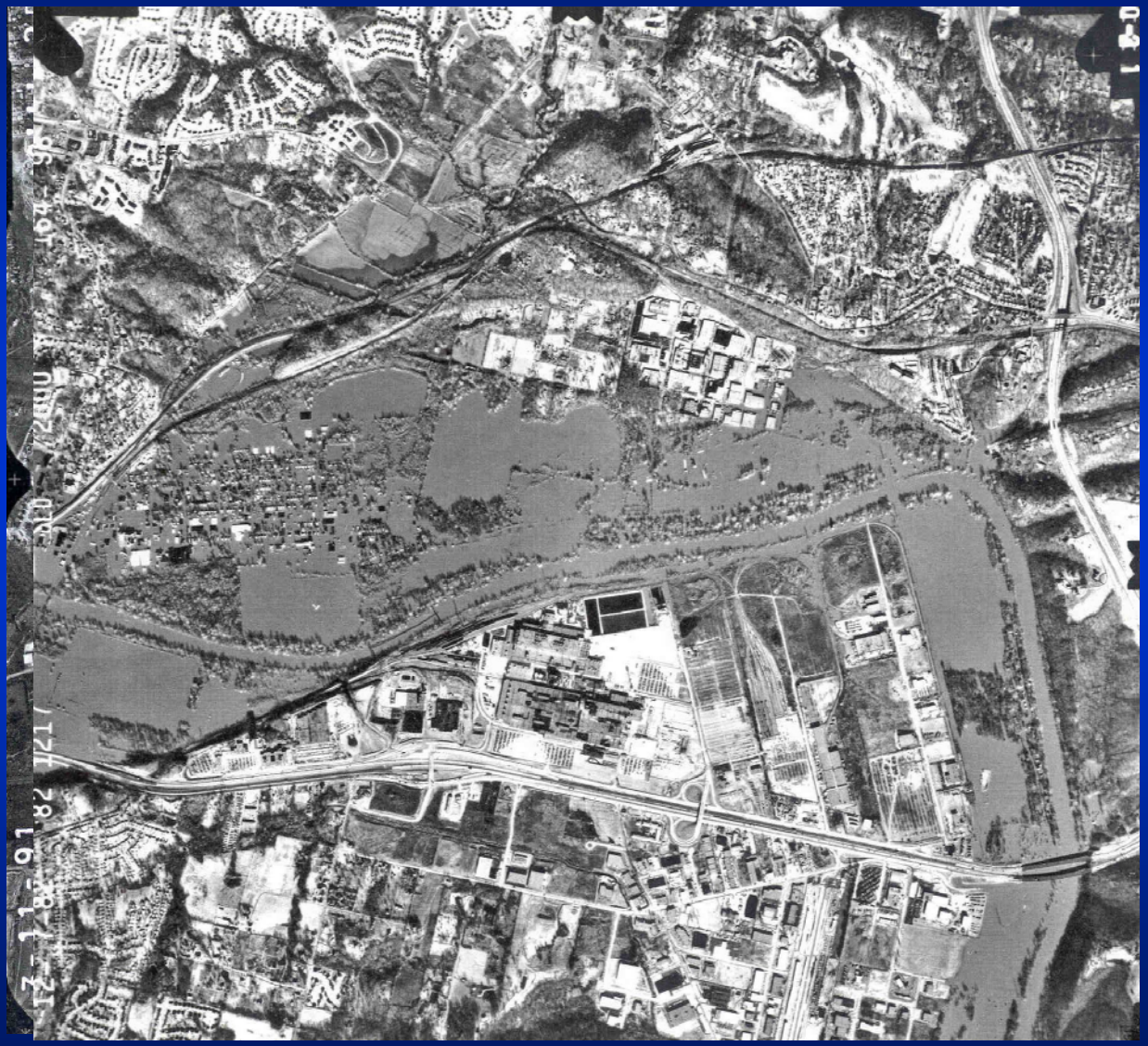
Location of Valley Park, MO.



One Corps Serving the Armed Forces and the Nation

US Army Corps of Engineers

Extent of Flooding



US Army Corps of Engineers

Meramec River – 1982 Flood of Record

US Army Corps of Engineers

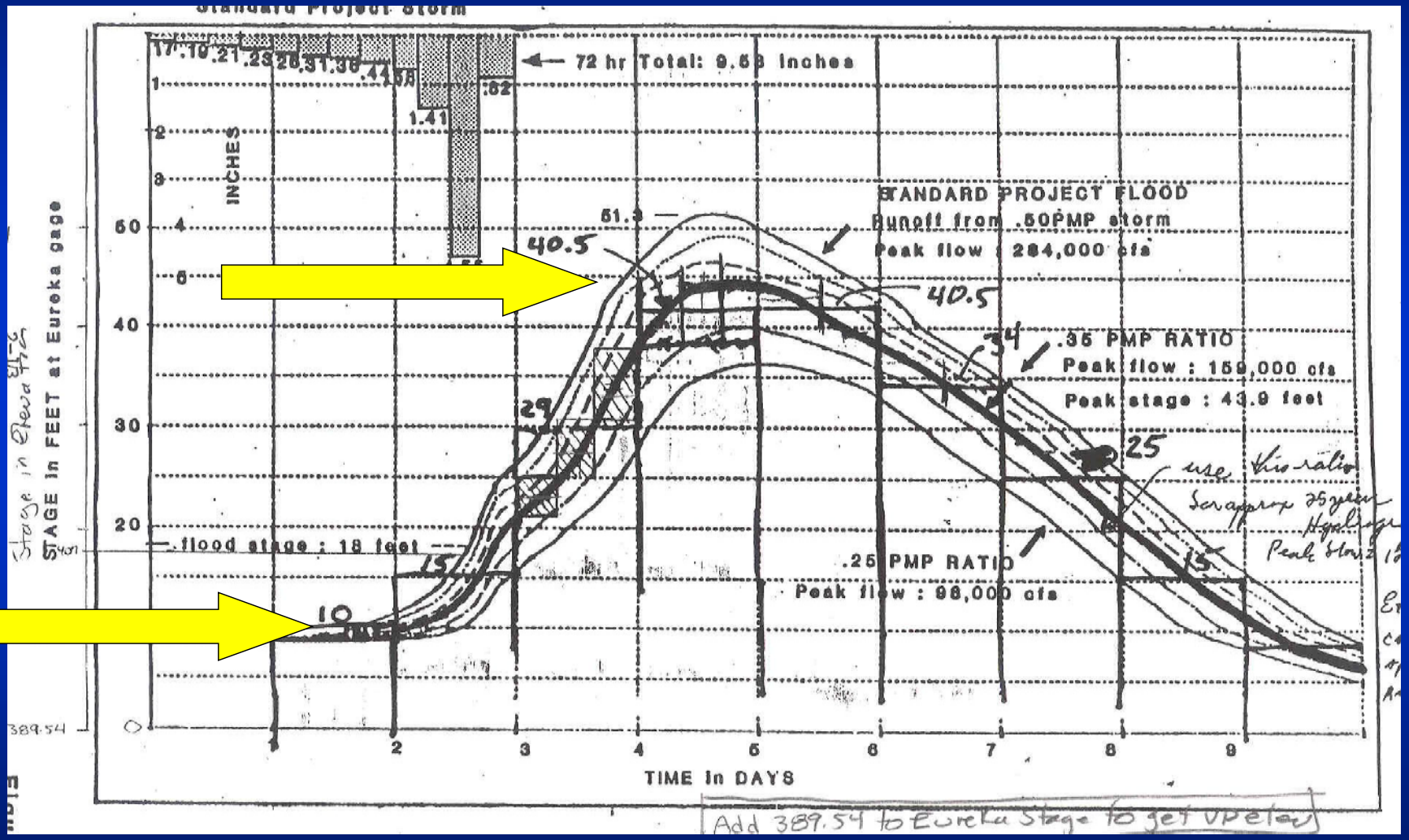
Meramec River – 1982 Flood of Record

US Army Corps of Engineers

Meramec River – 1982 Flood of Record

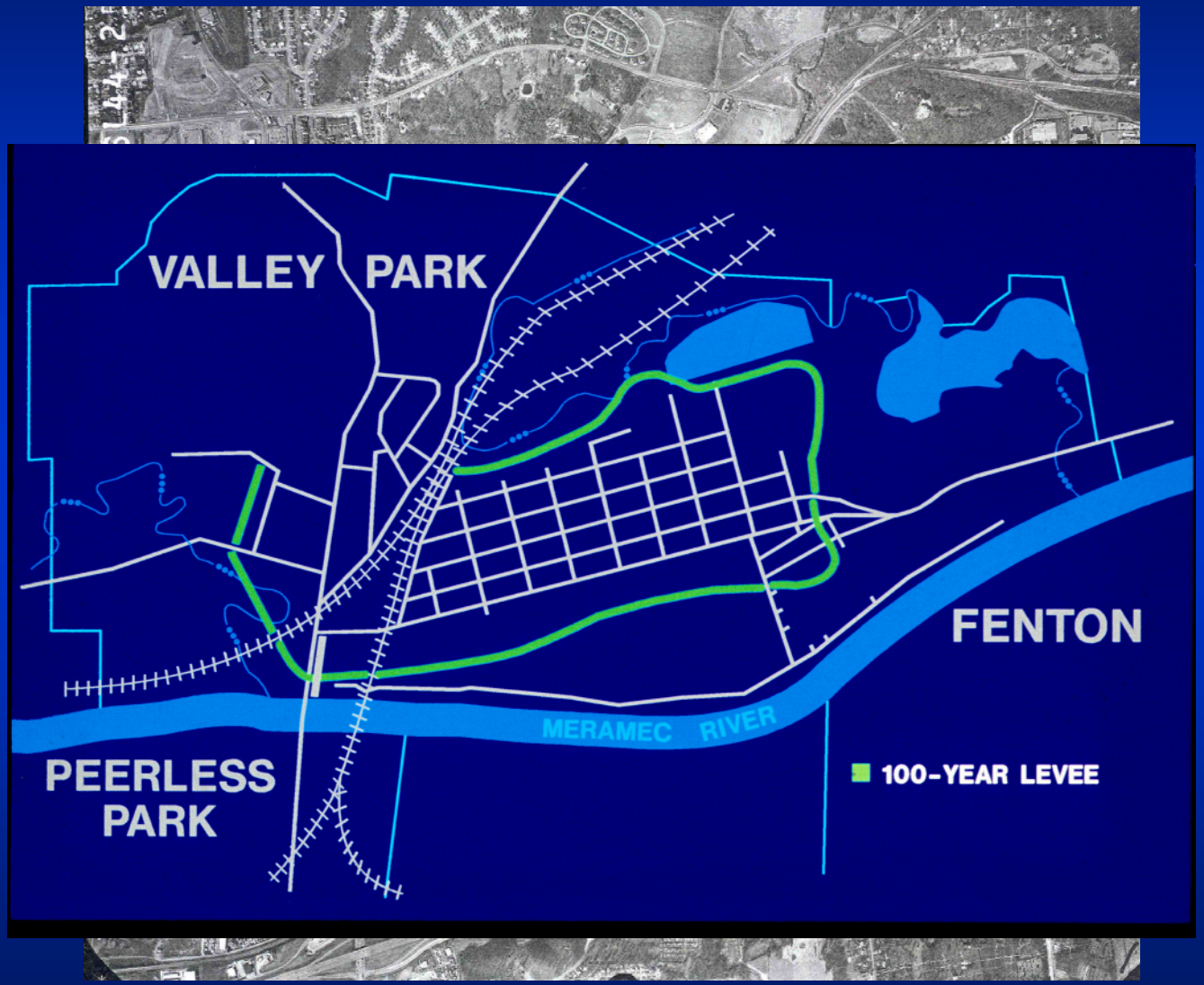
US Army Corps of Engineers

Stage Hydrograph



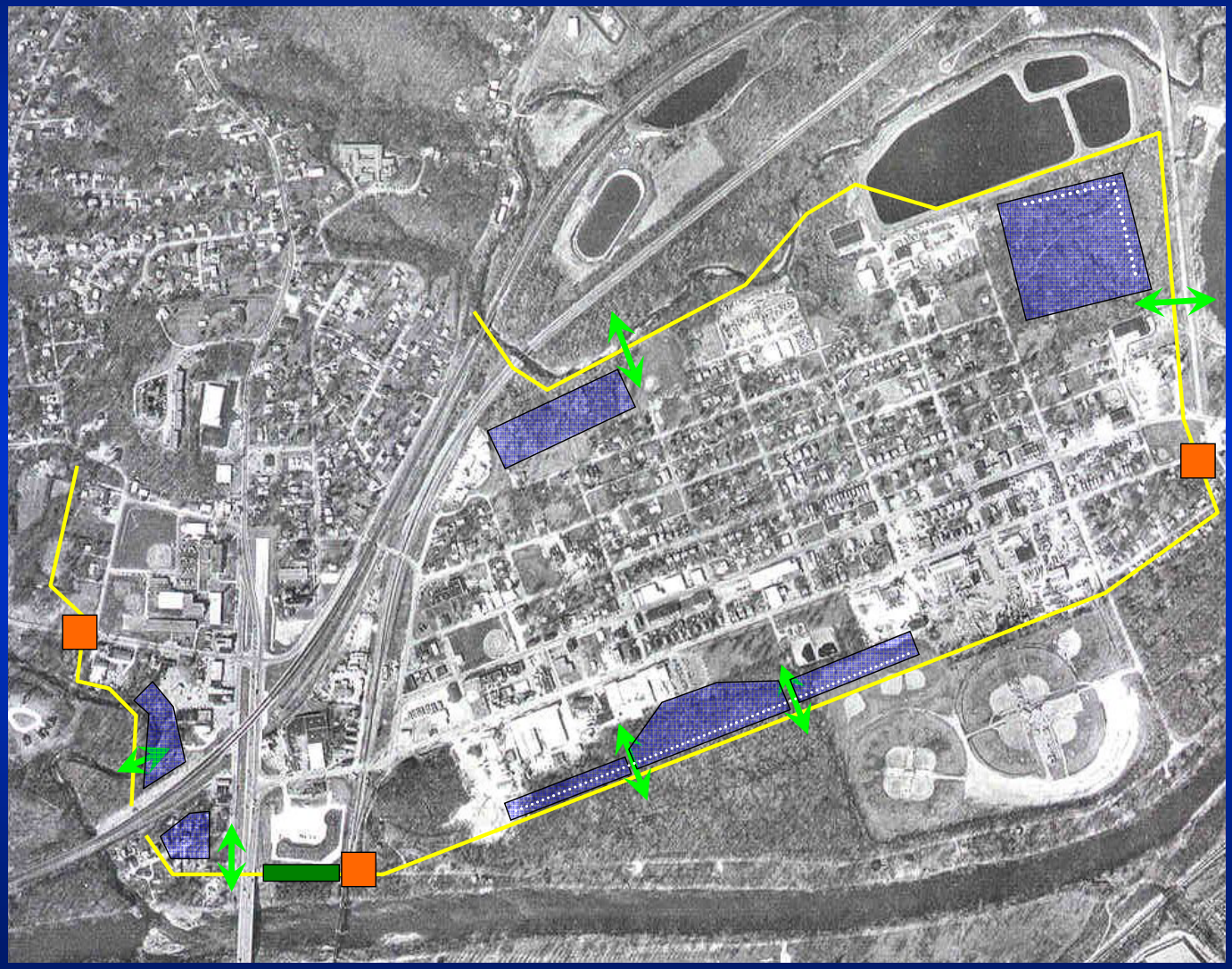
US Army Corps of Engineers

Alignment of 100-Yr Flood Protection Project.



US Army Corps of Engineers

Details of the Valley Park Levee.



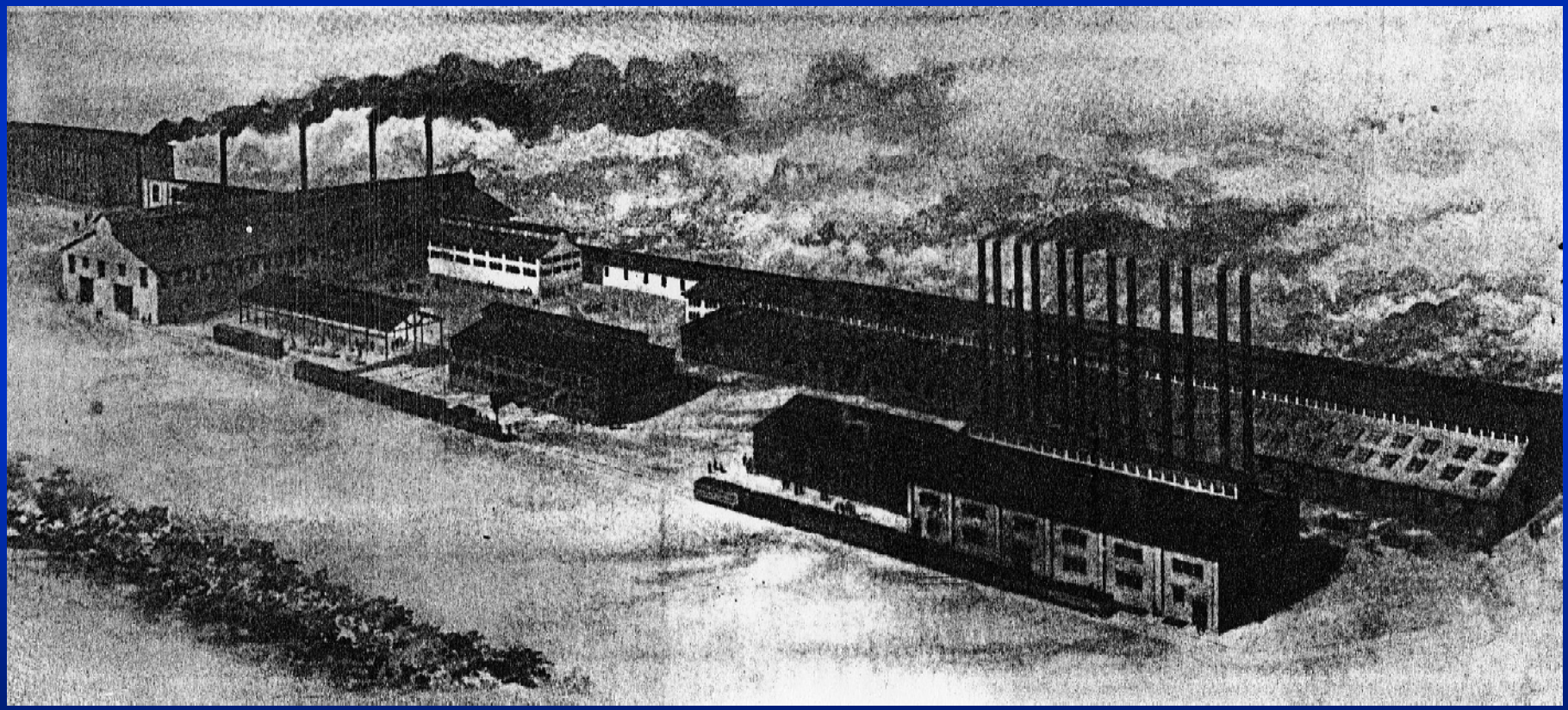
US Army Corps of Engineers

Design and Construction Challenges

- Relocation of many aerial and buried utilities.
- Closure structures across arterial roads.
- Closure structure across active main line railroad.
- Crossing sewage treatment plant surge lagoon.
- Confusing real estate.
- Dealing with of buried hazardous and special wastes.
- TCE contamination in the groundwater.
- Two existing creek relocations/realignments.
- Stream bank, hardwood and wetland mitigation.
- Induced flooding in FEMA floodway.
- Glass Plant foundation ruins.

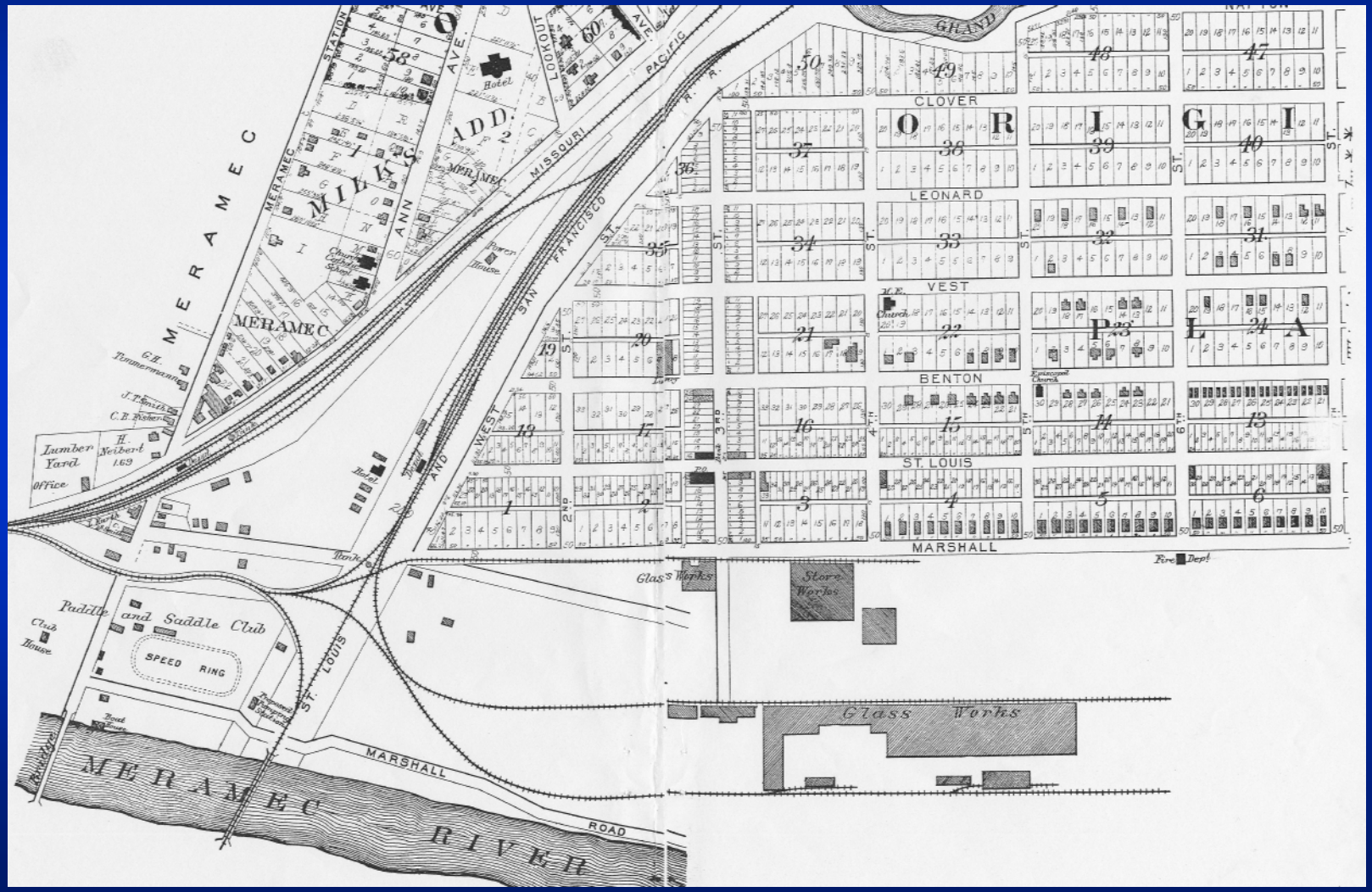
US Army Corps of Engineers

St. Louis Plate Glass Company
Artists Rendering – Circa 1909



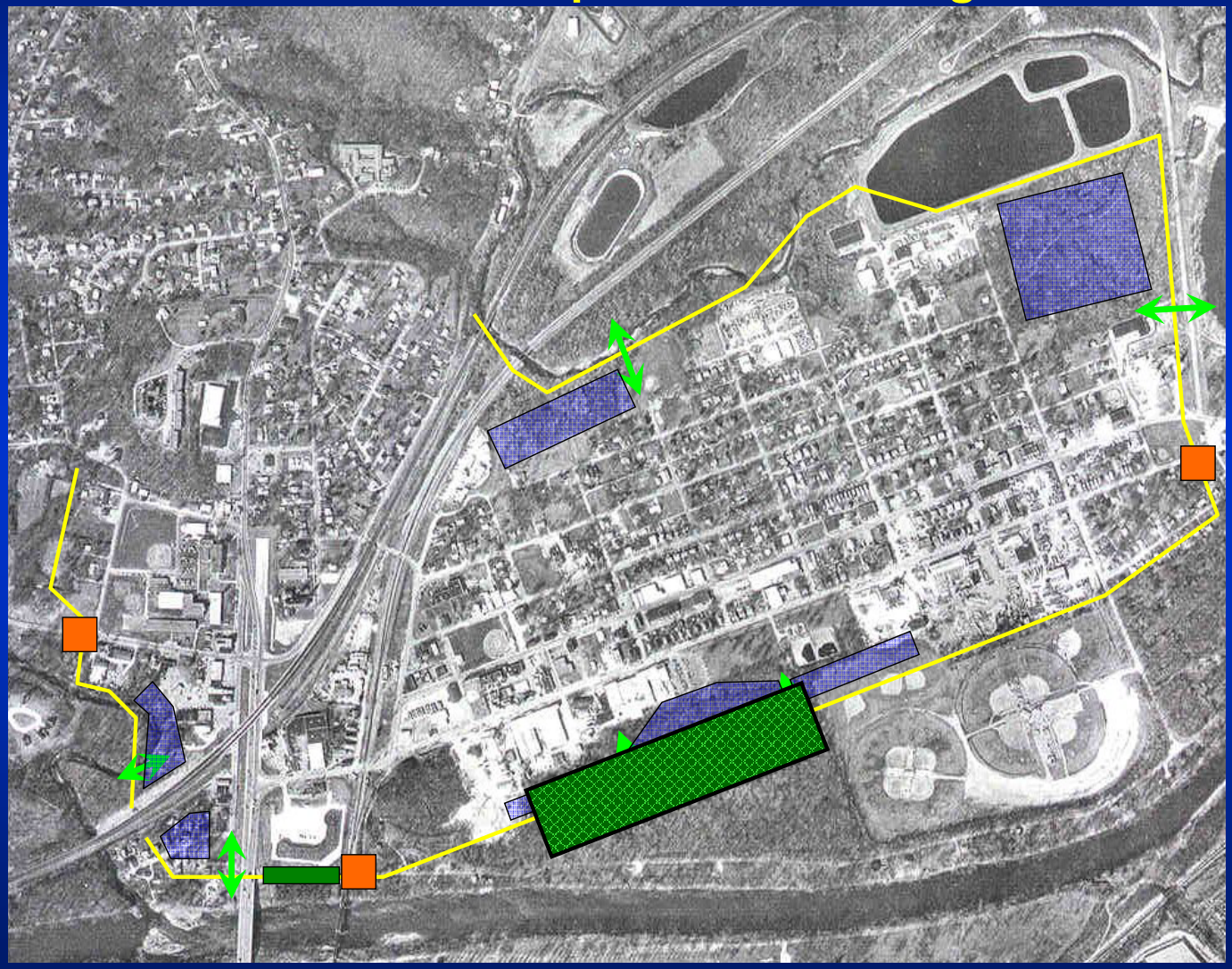
US Army Corps of Engineers

St. Louis Plate Glass Company Plant Location – Circa 1909



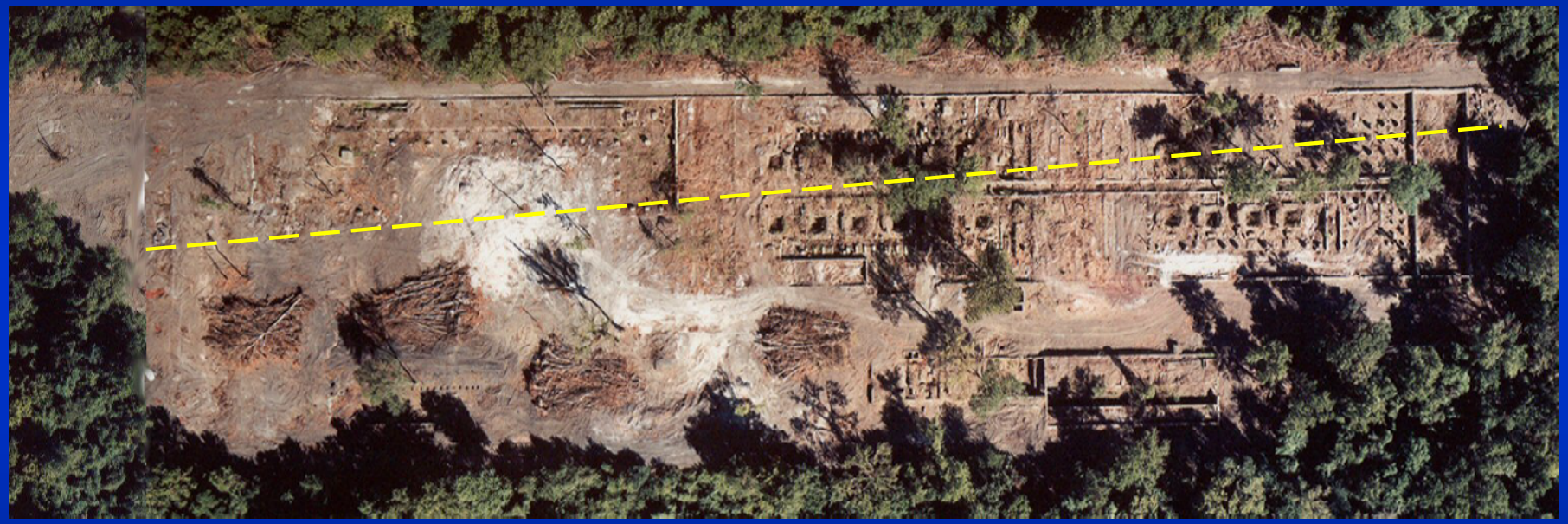
US Army Corps of Engineers

St. Louis Plate Glass Company
Location With Respect to Levee Alignment



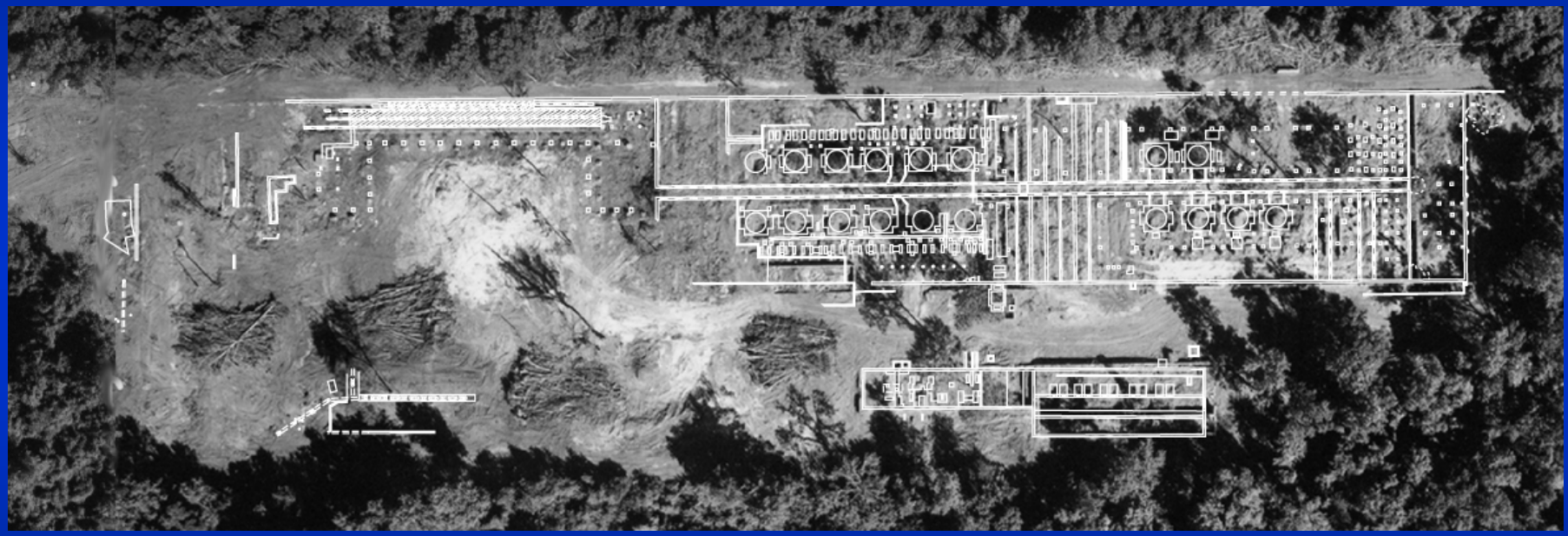
US Army Corps of Engineers

St. Louis Plate Glass Company
Extent of Ruins



US Army Corps of Engineers

St. Louis Plate Glass Company
Extent of Ruins



US Army Corps of Engineers

Glass Plant Conditions after 85 Years

US Army Corps of Engineers

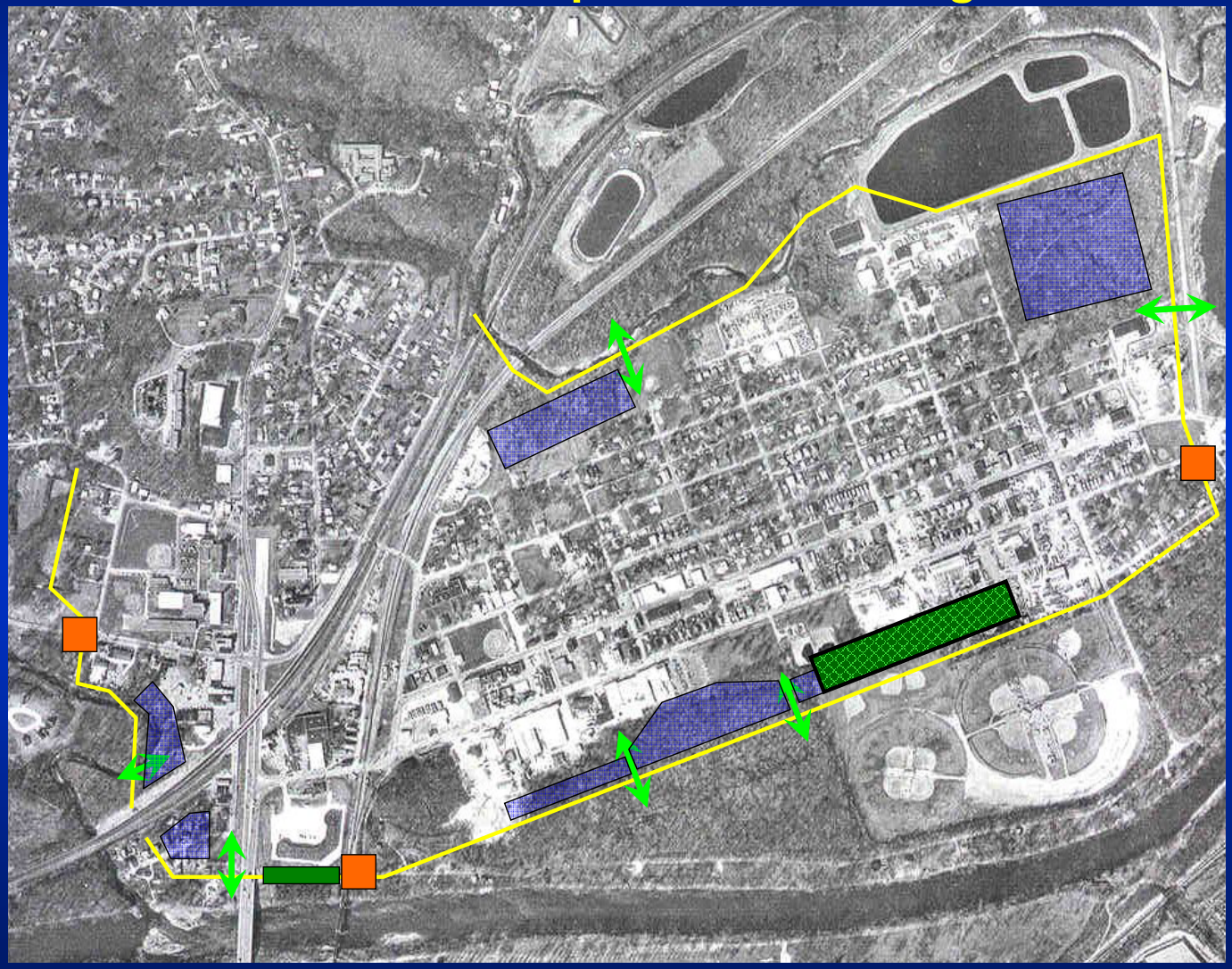
Glass Plant Conditions after 85 Years

US Army Corps of Engineers

Glass Plant Conditions after 85 Years

US Army Corps of Engineers

Absorbent Cotton Company
Location With Respect to Levee Alignment



US Army Corps of Engineers

Absorbent Cotton Material

US Army Corps of Engineers

Absorbent Cotton Material

US Army Corps of Engineers

How to Deal With Waste Products? Haul Off-Site?

- **Haul Off-Site**
  - Original Plan per 1993 Feature Design Memorandum
  - Hauling and disposal costs have skyrocketed since 1983.
  - MO Department of Natural Resources not satisfied with possible use of storage volume in local landfill.
  - Have to replace volume with suitable off-site borrow.
  - The St. Louis District estimated a total volume of 185,000 cu-yds of material.

US Army Corps of Engineers

How to Deal With Ruins?
Leave In-Place and Realign Levee?

- **Two Significant Restraints**
  - **Levee alignment can't move riverside because FEMA floodway is near the existing riverside levee toe. Calculated levels of induced flooding upstream are unacceptable.**
  - **Levee alignment can't move landside because existing development is in the way. Real estate costs to purchase industrial property makes this infeasible.**

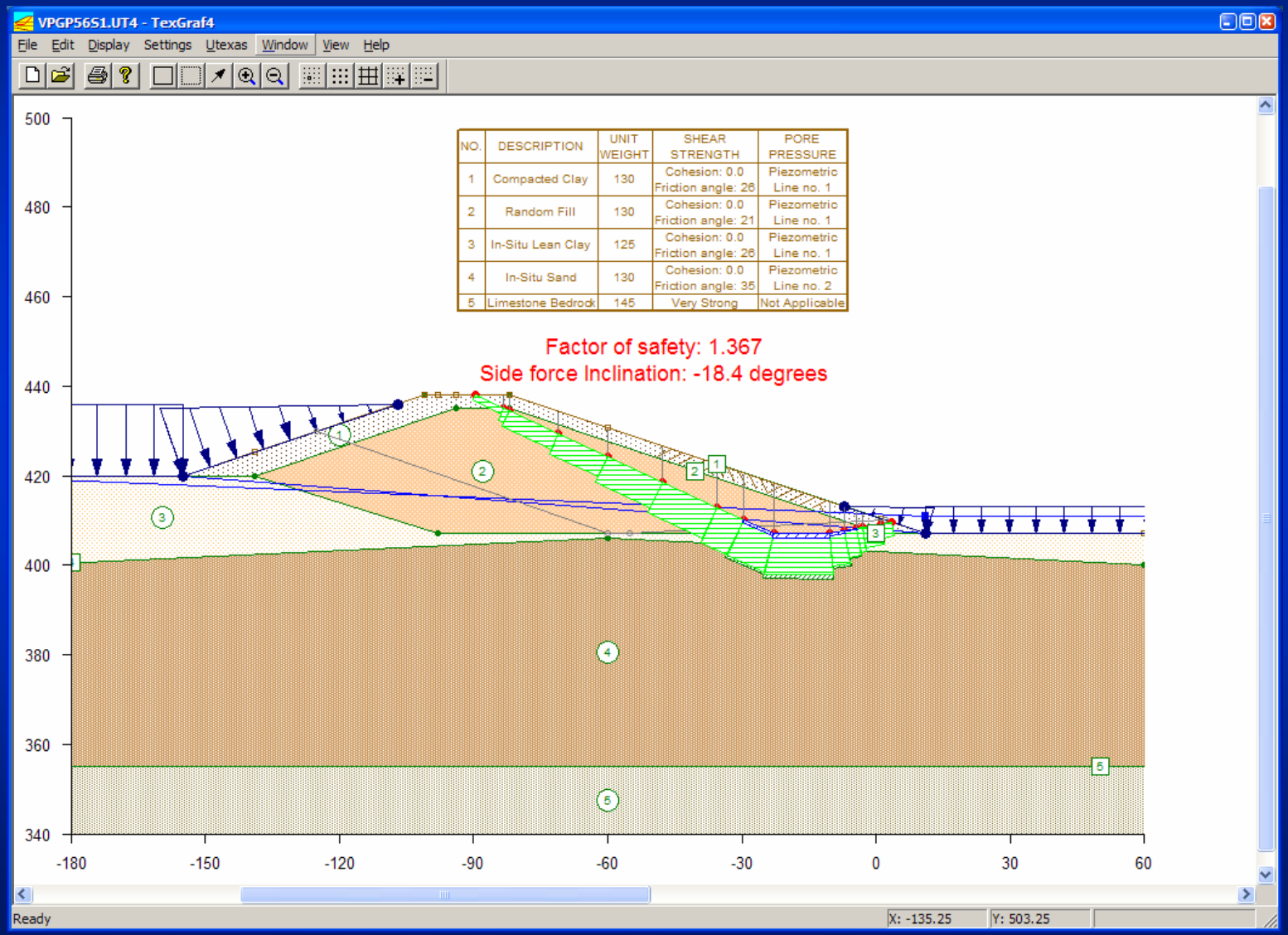
US Army Corps of Engineers

How to Deal With Ruins? Recycle and Reuse?

- St. Louis District investigated crushing the concrete and blending it with two other waste products that were on-site.
- These waste products included:
  - Cinders and slag
  - Absorbant Cotton material.
- The District decided to explore crushing the concrete and blending it with the other two waste products.
- We called it 'Engineered Fill'.

US Army Corps of Engineers

Slope Stability Analyses of Engineered Fill Section.



US Army Corps of Engineers

Specifications for Engineered Fill

- Concrete crushed to 4”(-) size.
- Initial Blending Ratios:
  - 20% Crushed Concrete
  - 65% Cinders/slag
  - 15% Absorbent Cotton Materials.
- Test Fill Required Before Advancing to Production.

US Army Corps of Engineers

Concrete Ruins – Initial Excavation

US Army Corps of Engineers

Concrete Ruins – Initial Excavation

US Army Corps of Engineers

Concrete Ruins – Initial Excavation

US Army Corps of Engineers

Concrete Ruins – Rock Hammer Reduction

US Army Corps of Engineers

Concrete Ruins – Rock Hammer Reduction

US Army Corps of Engineers

Concrete Ruins - Crushing

US Army Corps of Engineers

Concrete Ruins - Crushing

US Army Corps of Engineers

Concrete Ruins - Crushing

US Army Corps of Engineers

Concrete Ruins – Crushing Movie

US Army Corps of Engineers

Concrete Ruins - Crushing

US Army Corps of Engineers

Concrete Ruins - Crushing

US Army Corps of Engineers

Cinder Excavation

US Army Corps of Engineers

Cinder Excavation

US Army Corps of Engineers

Cinder Excavation

US Army Corps of Engineers

Blending Operations Portable Package

US Army Corps of Engineers

Blending Operations
Three Individual Hoppers

US Army Corps of Engineers

Blending Operations – Conveyor Belt

US Army Corps of Engineers

Blending Operations – Stacker

US Army Corps of Engineers

Blending Operations
Crushed Concrete Load

US Army Corps of Engineers

Blending Operations – Cinder Load

US Army Corps of Engineers

Blending Operations - Stockpiling

US Army Corps of Engineers

Blending Operations

US Army Corps of Engineers

Blending Operations
Top Load Into Trucks

US Army Corps of Engineers

Inspection Trench Completed

US Army Corps of Engineers

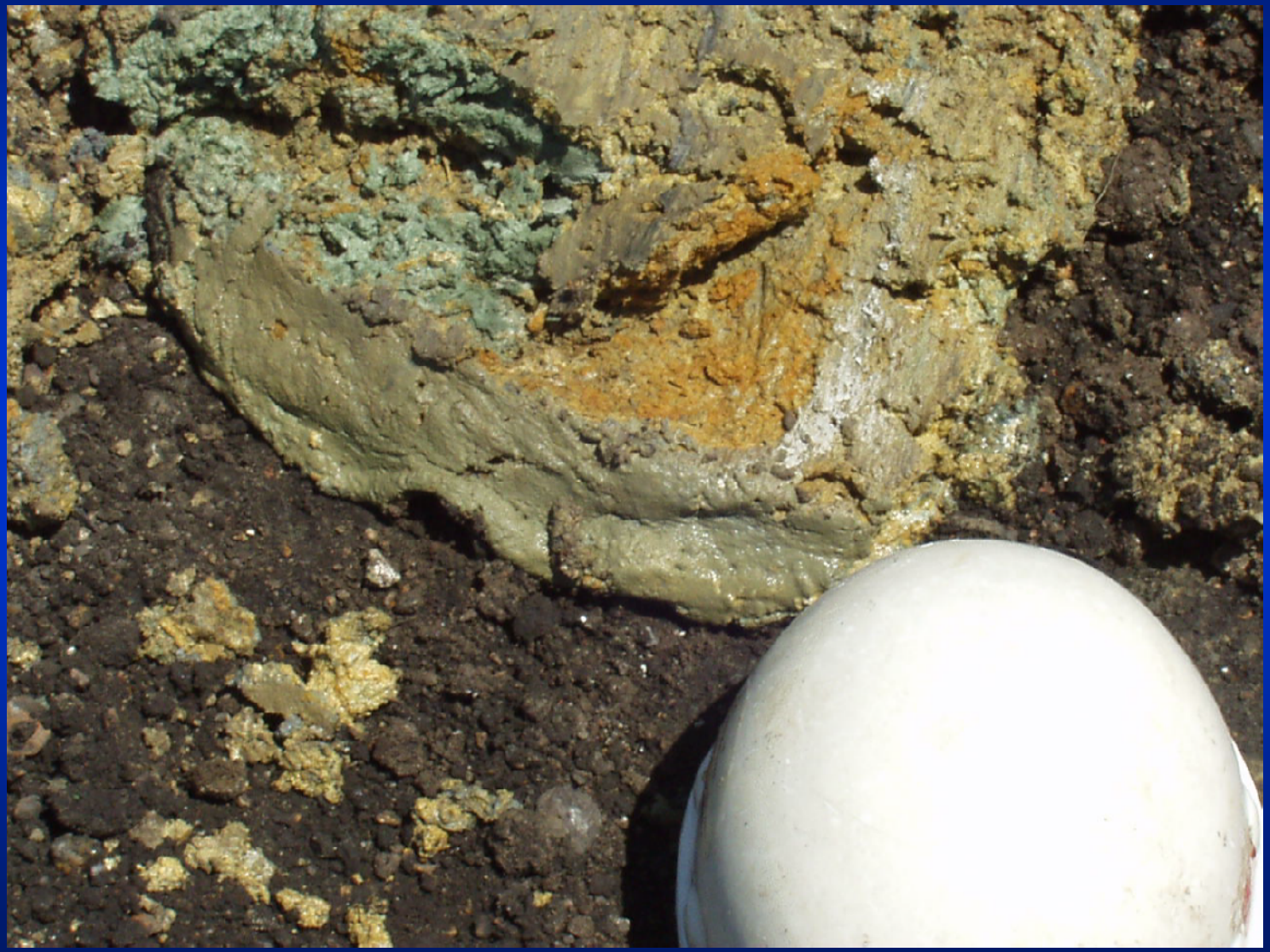
Engineered Fill -Test Fill

US Army Corps of Engineers

Absorbent Cotton Material

US Army Corps of Engineers

Absorbent Cotton Material



US Army Corps of Engineers

Absorbent Cotton - Spreading

US Army Corps of Engineers

Engineered Fill – Disking Test Fill

US Army Corps of Engineers

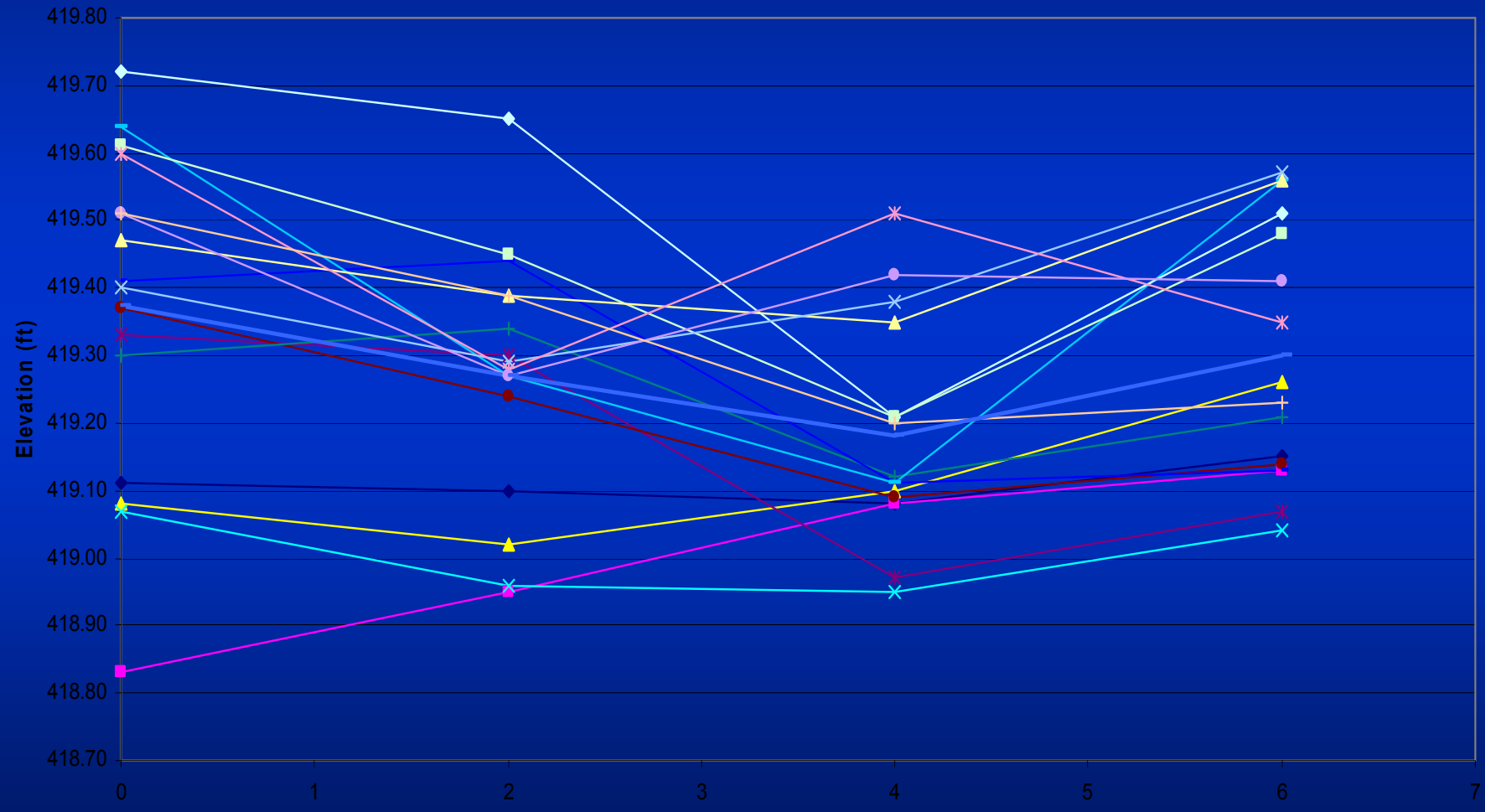
Engineered Fill – Compacting Test Fill

US Army Corps of Engineers

Test Fill Pumping Under Roller

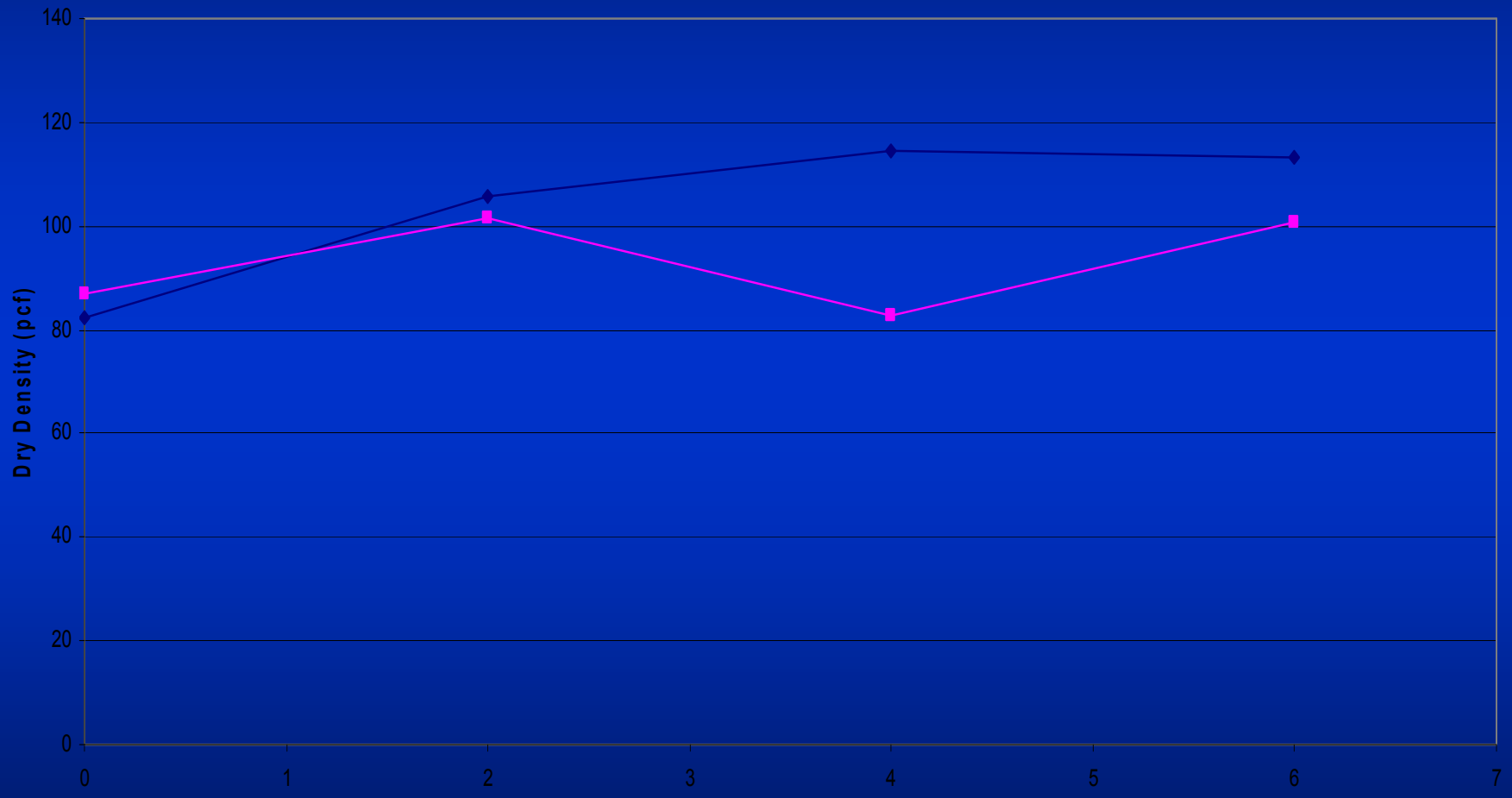
US Army Corps of Engineers

Engineered Fill Test Fill - 5th Lift Elevations vs Number of Passes



US Army Corps of Engineers

Engineered Fill Test Fill - 5th Lift
Dry Density vs Number of Passes



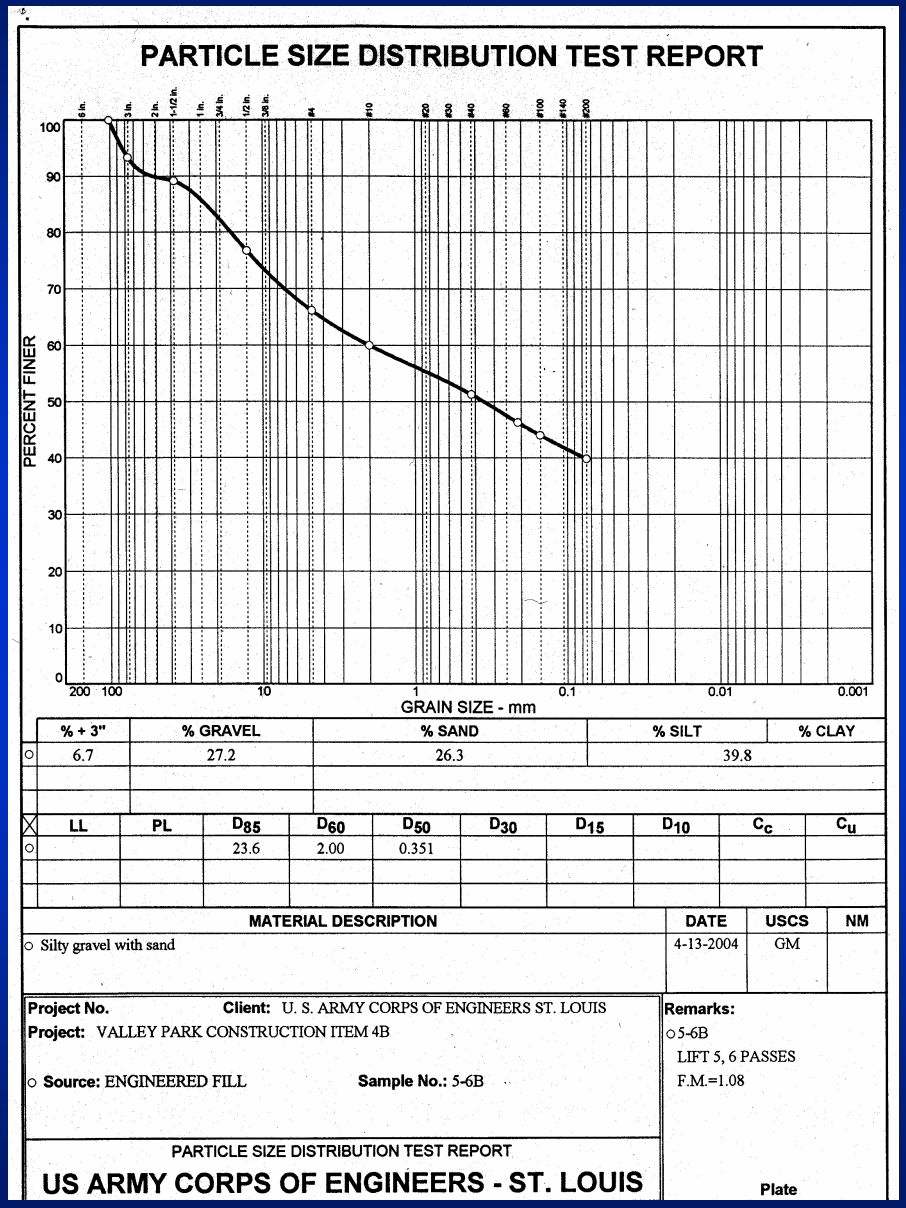
US Army Corps of Engineers

Test Fill Inspection Trench

US Army Corps of Engineers

Test Fill Inspection Trench

US Army Corps of Engineers



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
6.7	27.2	26.3	39.8	

LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
		23.6	2.00	0.351					

MATERIAL DESCRIPTION	DATE	USCS	NM
Silty gravel with sand	4-13-2004	GM	

Project No. **Client:** U. S. ARMY CORPS OF ENGINEERS ST. LOUIS

Project: VALLEY PARK CONSTRUCTION ITEM 4B

Source: ENGINEERED FILL **Sample No.:** 5-6B

Remarks:
5-6B
LIFT 5, 6 PASSES
F.M.=1.08

PARTICLE SIZE DISTRIBUTION TEST REPORT

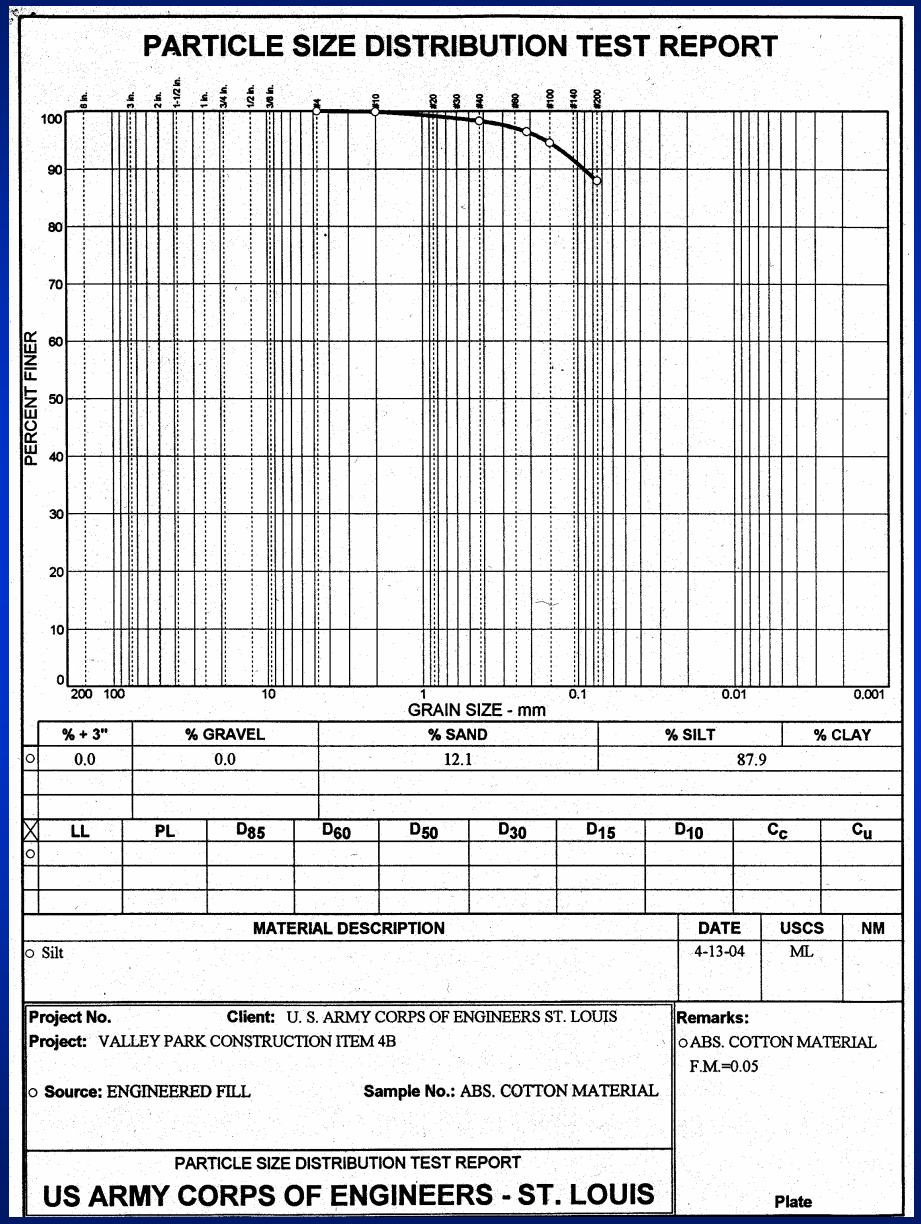
US ARMY CORPS OF ENGINEERS - ST. LOUIS

Plate

Results of Sieve Analyses

Engineered Fill Material

US Army Corps of Engineers



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	12.1	87.9	

LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u

MATERIAL DESCRIPTION	DATE	USCS	NM
○ Silt	4-13-04	ML	

Project No. **Client:** U. S. ARMY CORPS OF ENGINEERS ST. LOUIS
Project: VALLEY PARK CONSTRUCTION ITEM 4B
○ **Source:** ENGINEERED FILL **Sample No.:** ABS. COTTON MATERIAL

PARTICLE SIZE DISTRIBUTION TEST REPORT
US ARMY CORPS OF ENGINEERS - ST. LOUIS

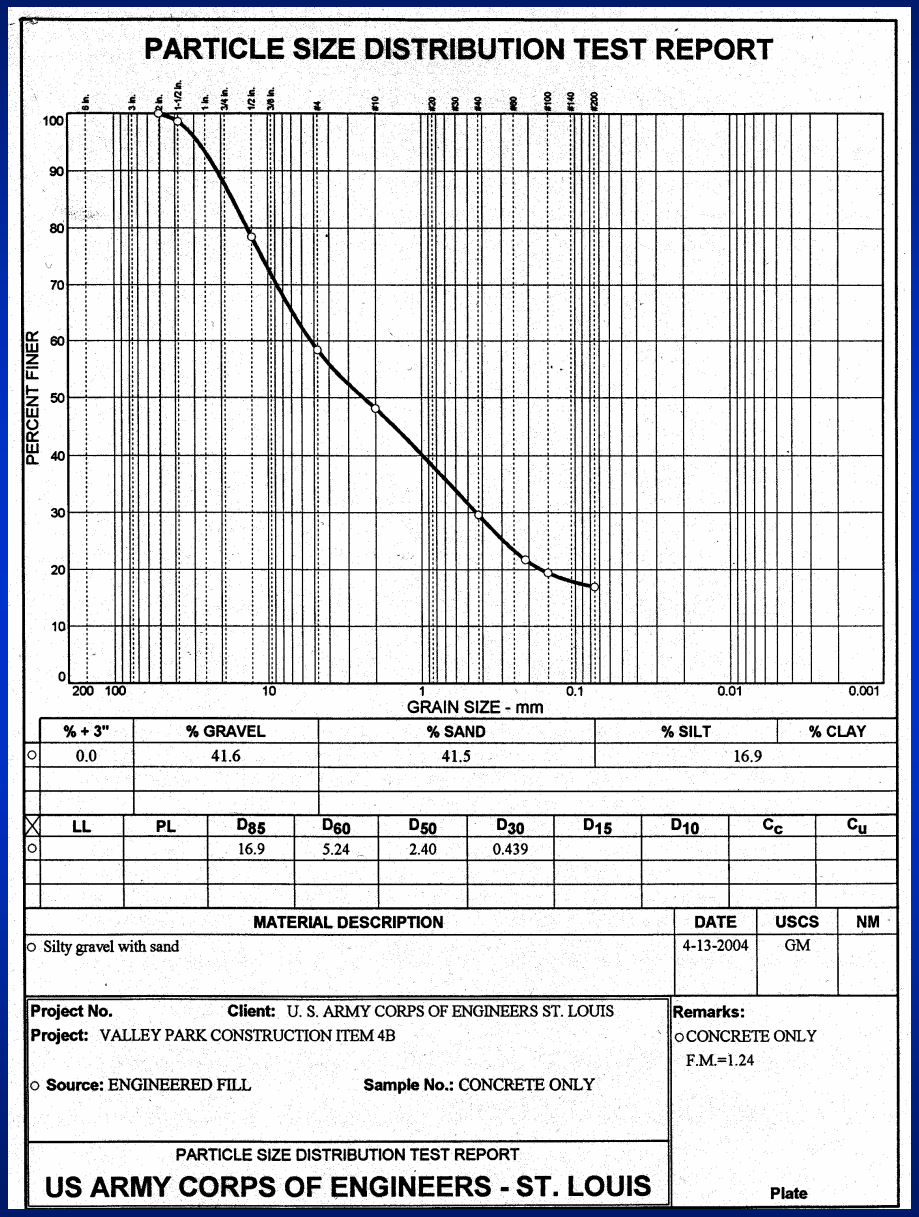
Remarks:
○ ABS. COTTON MATERIAL
F.M.=0.05

Plate

Results of Sieve Analyses

Absorbent Cotton Material

US Army Corps of Engineers



% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
0.0	41.6	41.5	16.9	

LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
		16.9	5.24	2.40	0.439				

MATERIAL DESCRIPTION	DATE	USCS	NM
Silty gravel with sand	4-13-2004	GM	

Project No. **Client:** U. S. ARMY CORPS OF ENGINEERS ST. LOUIS
Project: VALLEY PARK CONSTRUCTION ITEM 4B
Source: ENGINEERED FILL **Sample No.:** CONCRETE ONLY

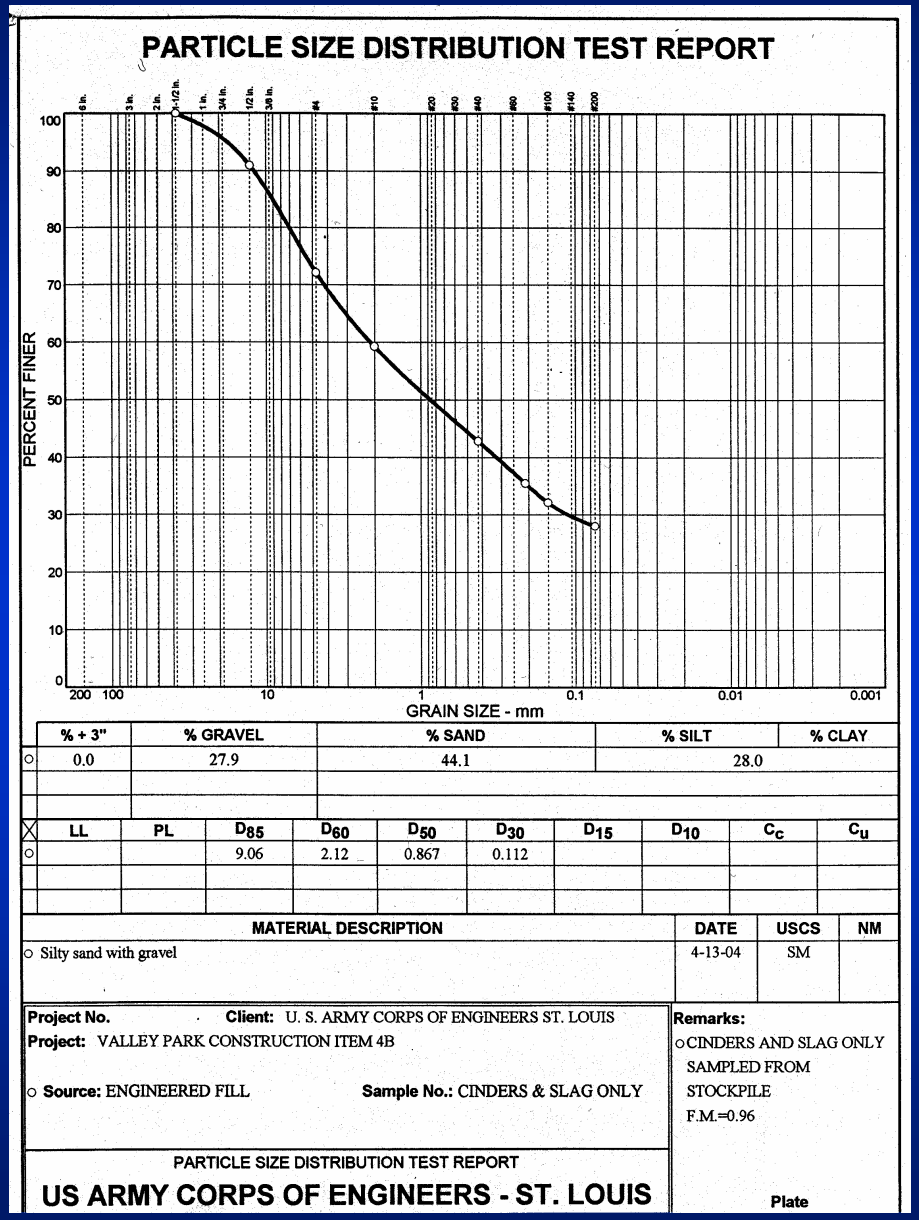
Remarks:
CONCRETE ONLY
F.M.=1.24

PARTICLE SIZE DISTRIBUTION TEST REPORT
US ARMY CORPS OF ENGINEERS - ST. LOUIS
Plate

Results of Sieve Analyses

Crushed Concrete

US Army Corps of Engineers



PARTICLE SIZE DISTRIBUTION TEST REPORT

PERCENT FINER

GRAIN SIZE - mm

	% + 3"	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	27.9	44.1	28.0	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			9.06	2.12	0.867	0.112				

MATERIAL DESCRIPTION	DATE	USCS	NM
○ Silty sand with gravel	4-13-04	SM	

Project No. **Client:** U. S. ARMY CORPS OF ENGINEERS ST. LOUIS
Project: VALLEY PARK CONSTRUCTION ITEM 4B
○ **Source:** ENGINEERED FILL **Sample No.:** CINDERS & SLAG ONLY

Remarks:
○ CINDERS AND SLAG ONLY SAMPLED FROM STOCKPILE
F.M.=0.96

PARTICLE SIZE DISTRIBUTION TEST REPORT
US ARMY CORPS OF ENGINEERS - ST. LOUIS

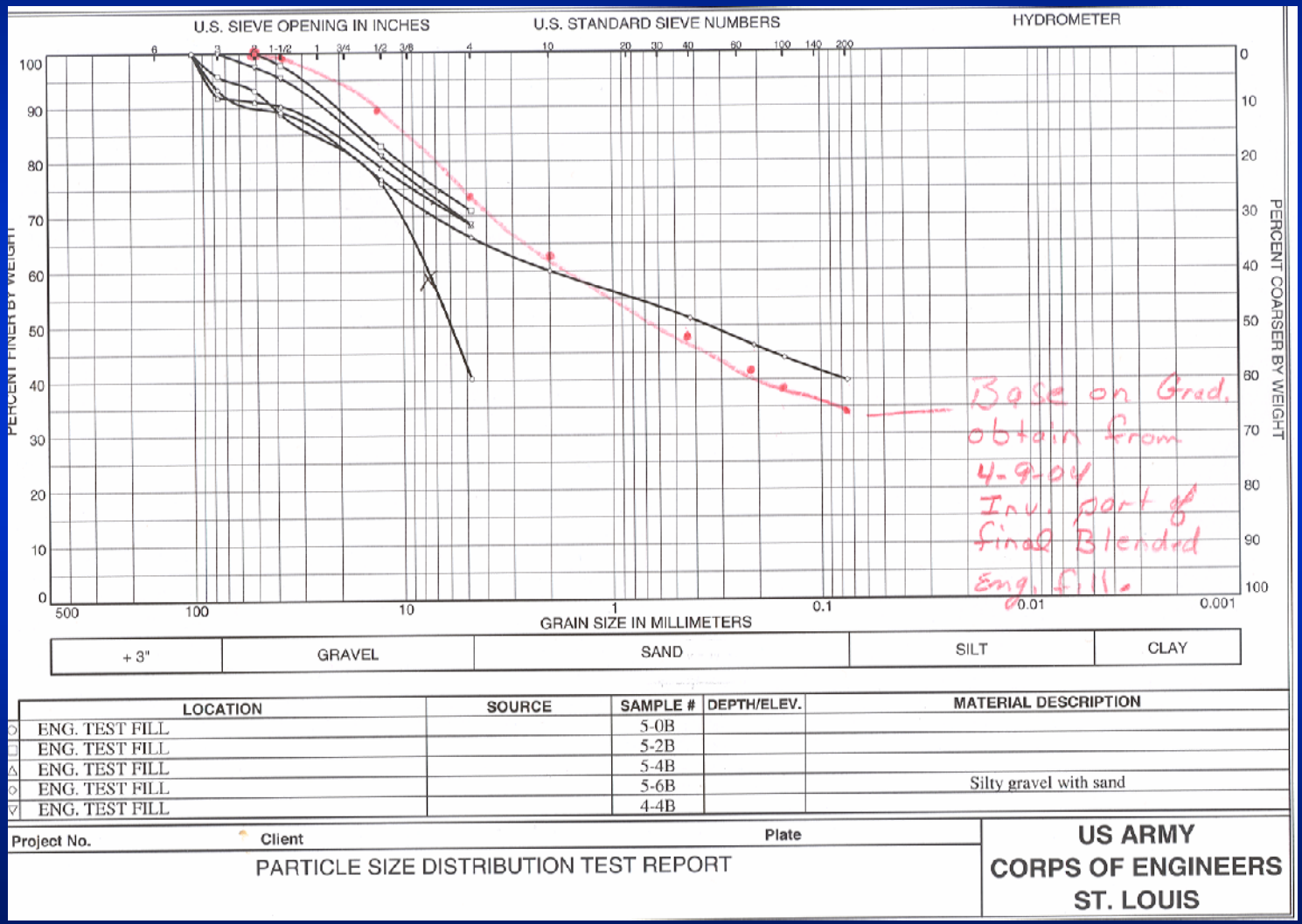
Plate

Results of Sieve Analyses

Cinders and Slag

US Army Corps of Engineers

Results of Sieve Analyses
Measured Engineered Fill and Theoretical Computations



	LOCATION	SOURCE	SAMPLE #	DEPTH/ELEV.	MATERIAL DESCRIPTION
○	ENG. TEST FILL		5-0B		
□	ENG. TEST FILL		5-2B		
△	ENG. TEST FILL		5-4B		
◇	ENG. TEST FILL		5-6B		Silty gravel with sand
▽	ENG. TEST FILL		4-4B		

Project No. | Client | Plate

PARTICLE SIZE DISTRIBUTION TEST REPORT

US ARMY CORPS OF ENGINEERS ST. LOUIS

US Army Corps of Engineers

Drilling Hole for Pressuremeter

US Army Corps of Engineers

Drilling Hole for Pressuremeter

US Army Corps of Engineers

Menard Style Pressuremeter

US Army Corps of Engineers

Pressuremeter Control Panel

US Army Corps of Engineers

Some Pressuremeter Damage

US Army Corps of Engineers

Typical Menard Pressuremeter Results

PRESSUREMETER TEST RESULTS

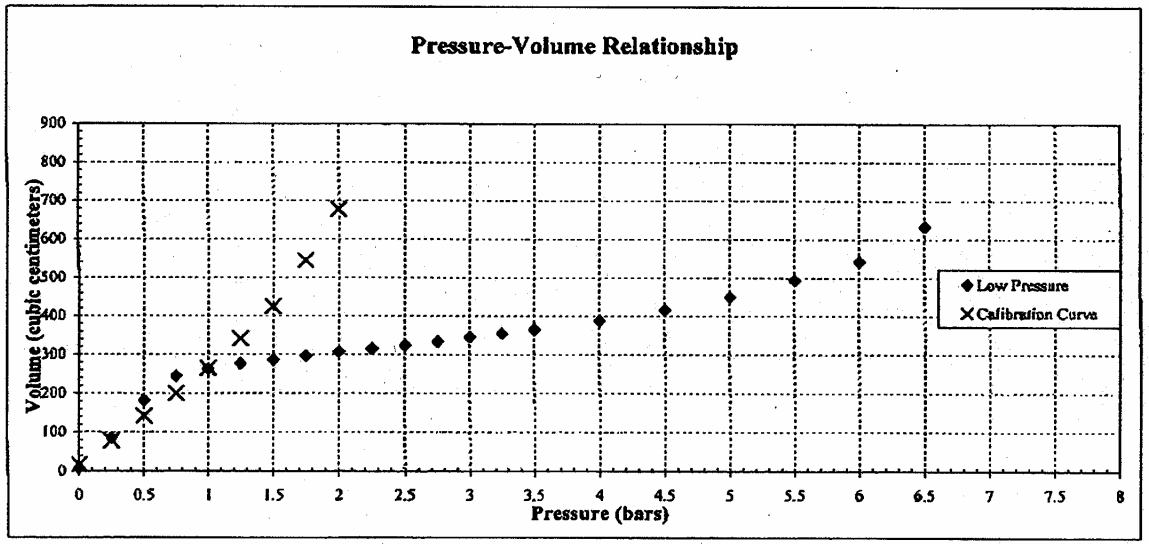
Project Description: Valley Park Floodwall
Project Number:
Client: Brotcke Well & Pump

Date: 6/15/2004
Page: 1 of 1
Approved By: JS

Boring No: PMT-2
Depth: 4 ft
Sample Description: Engineered Fill; Crushed Concrete and Bricks, Slag, Cinders and Fibrous Cotton Residue
Project Stationing: Station 46+62

Surface Elevation: 426.9 ft
Test Elevation: 422.9 ft

Pressure Increment (bars)	60 Sec. Reading (cc)
0	8
0.25	84
0.5	182
0.75	244
1	263
1.25	277
1.5	286
1.75	297
2	307
2.25	315
2.5	324
2.75	334
3	346
3.25	355
3.5	366
4	388
4.5	416
5	450
5.5	493
6	542
6.5	633



Modulus, E_m 65 bars / 136 ksf
Limit Pressure, p_l 4.8 bars / 10.1 ksf

Pressure Increment for Em, (bars)	*1*	*2*
Volume Increment for Em, (cc)	*263*	*307*

P900 7 bars
P_i, # 2-Probe #4 2.3 bars

Undrained Shear Strength, S_u 0.7 bars / 1.4 ksf

KLEINFELDER

One Corps Serving the Armed Forces and the Nation

US Army Corps of Engineers

Menard Pressuremeter Results in Weak Layer

PRESSUREMETER TEST RESULTS

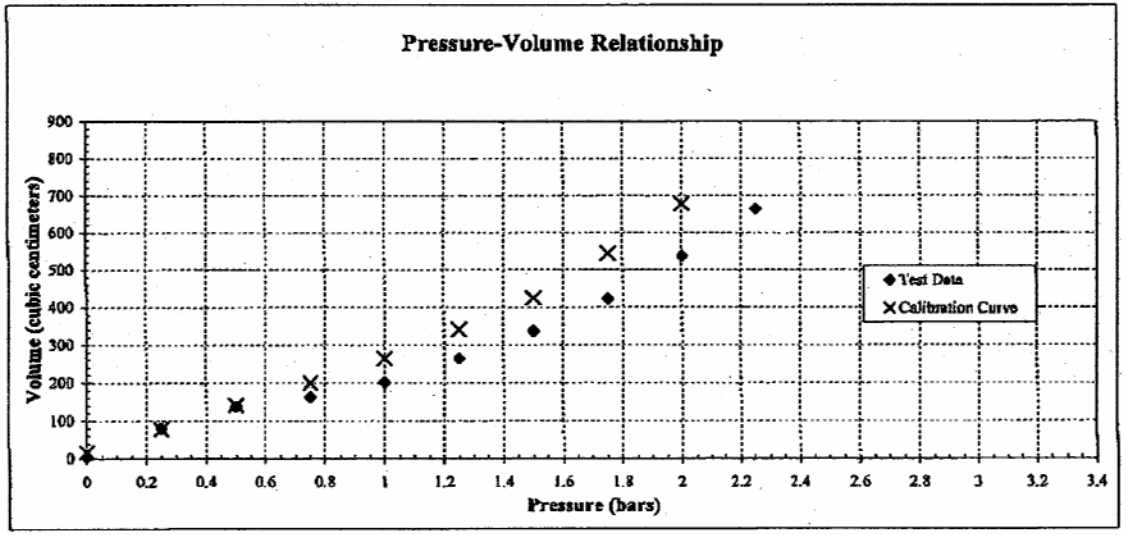
Project Description: Valley Park Floodwall
Project Number:
Client: Brotcke Well & Pump

Date: 6/15/2004
Page: 1 of 1
Approved By: JS

Boring No: PMT-2
Depth: 6 ft
Sample Description: Engineered Fill; Crushed Concrete and Bricks, Slag, Cinders and Fibrous Cotton Residue
Project Stationing: Station 46+62

Surface Elevation: 426.9 ft
Test Elevation: 420.9 ft

Pressure Increment (bars)	60 Sec. Reading (cc)
0	5
0.25	80
0.5	138
0.75	163
1	202
1.25	265
1.5	338
1.75	423
2	538
2.25	665



Modulus, E_m 20 bars / 42 ksf

Pressure Increment for Em, (bars)	*0.5*	*1*
Volume Increment for Em, (cc)	*138*	*202*

Limit Pressure, p_l 0.4 bars / 0.8 ksf

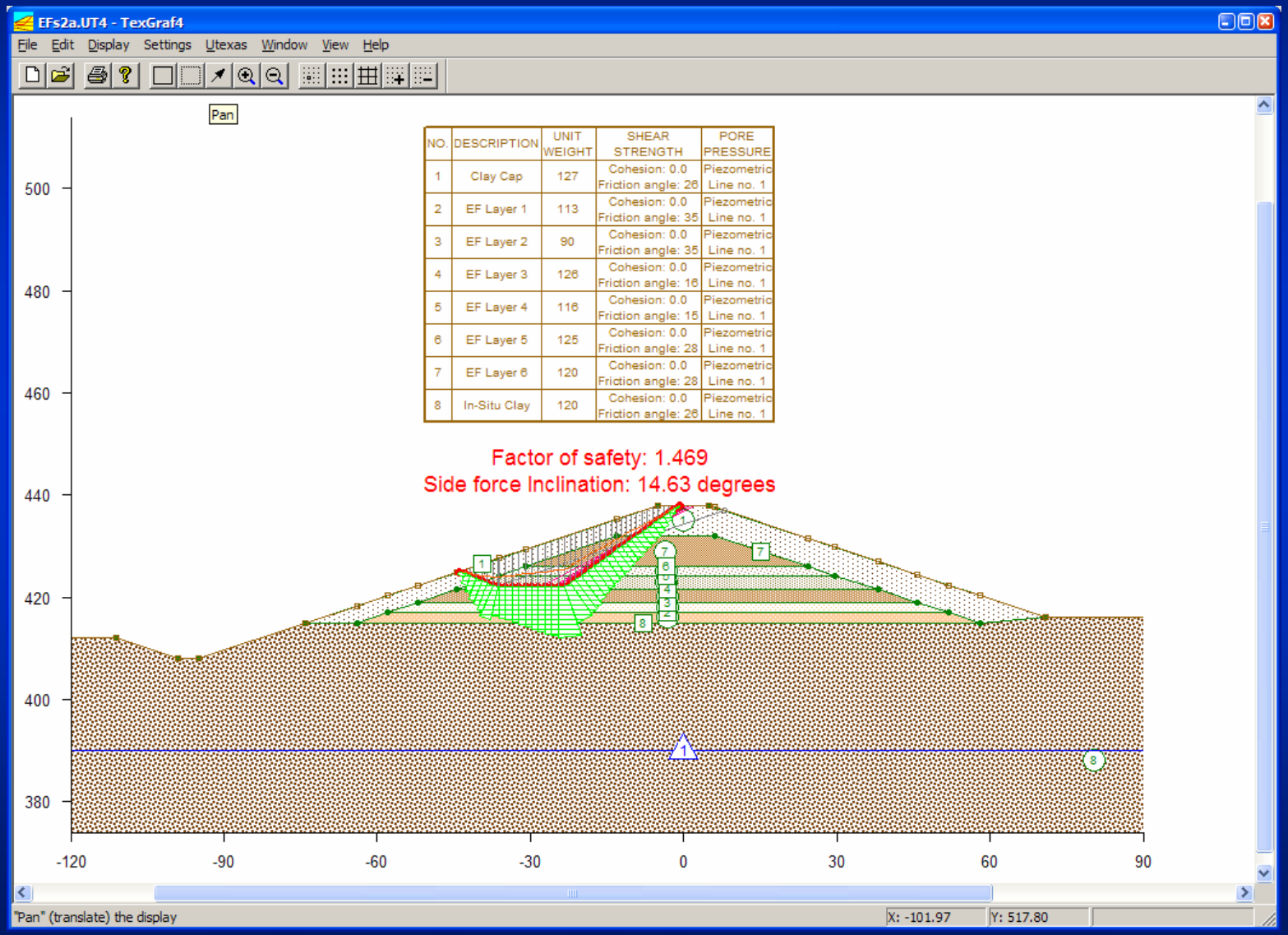
P900	*2.5 bars*
P_i, # 2-Probe #4	*2.3 bars*

KLEINFELDER

Undrained Shear Strength, S_u 0.1 bars / 0.2 ksf

US Army Corps of Engineers

Stability Analyses Using Pressuremeter Results.



US Army Corps of Engineers

Completed Section of Engineered Fill

US Army Corps of Engineers

Completed Levee Section

US Army Corps of Engineers

Flood Control Project Dedication

US Army Corps of Engineers

For More Information, Contact:

Patrick J. Conroy, P.E.

CEMVS-ED-GF

St. Louis District, U.S. Army Corps of Engineers

1222 Spruce Street,

St. Louis, MO 63103-2833

(314) 331-8432

Patrick.J.Conroy@MVS02.USACE.ARMY.MIL

US Army Corps of Engineers

THANK YOU

One Corps Serving the Armed Forces and the Nation