“FIVE FEET HIGH AND RISING”

Certifying the City of St. Louis Flood Protection System

by

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Chicago, IL

IAFSM Conference, Springfield, IL
March 8, 2017
“FIVE FEET HIGH AND RISING”

- Description of Flood Protection System
- Scope of Work
- Project Challenges
- Results
- Follow-up Projects
- Where are we now?
STL Flood Protection System

Authorized in 1955, Completed in 1974

6.75 miles of floodwall, 4.25 miles of levee, 28 pump stations, 39 closures

Protects 3,160 acres - predominantly commercial and industrial, about 900 people

Sponsors – City of St. Louis, Metropolitan St. Louis Sewer District
Flood of record – 49.6’ (August 1993)
Damages prevented $680,000,000

Built to withstand a flood of 52’ on the St. Louis gage.
**Hydraulics & Hydrology**
- Freeboard analysis
  - Discharge-stage probability
  - Stage-discharge uncertainty
- Interior Drainage
  - Pump Stations
  - Relief wells

**Interior Drainage**
- 44CFR65.10 deals with the issue of mapping; it is not written specifically to deal with "re-"accreditation"
- Document that system elements are in working order and covered under documented O&M procedures.
- A new interior drainage study would not be needed.

**Structural Analysis**
- Floodwalls
  - Strength analysis
  - Stability analysis
- Closure Structures (swing and panel gates)
  - Component analysis
  - Foundation analysis

**Geotechnical Analysis**
- Embankment Erosion
- Embankment & Foundation Stability
- Settlement Analysis
**Original Timeline**

- **March 19, 2010**: Project kickoff meeting
- **June, 2010**: Drilling/borings complete
- **October, 2010**: Draft report
- **November, 2010**: Final report
- **February, 2011**: Target completion date (PAL expiration)
PROJECT CHALLENGES

- High water
- Several delays
- Replacement gates
- Affected Geotechnical & Structural timelines
Upper Mississippi River System Flow Frequency Study

Stage-discharge uncertainty
Discharge-stage probability
PUMP STATION DRAINAGE AREAS
H&H / INTERIOR DRAINAGE

- USACE Design Memoranda
- Recent TV Inspections and Cleaning of Toe Drains
- Relief Wells Rehab and Replacement Project
- Physical Inspections of Pump Stations
PUMP STATION INSPECTIONS
PUMP STATION INSPECTIONS
STRUCTURAL ANALYSIS

As-built drawings
USACE Design Memoranda
2009 Periodic Inspection Report
Development of Spreadsheet Tools
Physical Inspections of System Elements
FLOODWALL INSPECTIONS
FLOODWALL INSPECTIONS
CLOSURE GATE INSPECTIONS
CLOSURE GATE INSPECTIONS
CLOSURE GATE INSPECTIONS
Done by Shannon & Wilson

USACE Design Memoranda

2009 Periodic Inspection Report

Original Construction Borings

Physical Inspections of System Elements

GEOTECHNICAL ANALYSIS
Levee Inspections
Levee Inspections
SCOPE OF WORK

Other Scope Items

- Operation, Maintenance, & Emergency Response Plans
- Certified As-Built Plans
- Probability of Failure and Consequences Failure Mode Analysis
- Submitted Draft Report in December, 2010
RESULTS

H & H Results
- Freeboard
- Interior drainage

Structural Results
- Flood Walls
- Closure Structures
- Trigen Energy/Closure C-2

Geotechnical Results
- Erosion, settlement
- Stability, Underseepage
STRUCTURAL RESULTS

Trigen Energy

Former U.E. Plant
ClosureC-2 panels and storage building sold for scrap.
Moving target – FEMA policy changes

February, 2011
Congressional letters

March, 2011
New methodology development

July, 2011
Community Roundtable Forum

December, 2011
Proposed approach for public review
FOLLOW-UP PROJECTS

• Abandoned Conduit Investigation
• New Closure C-2
• Riverview/Malone Creek Trench Drain
• Additional Swing Gates Analysis
• Trigen Plant Screen Well
C-2 STOPLOG STRUCTURE
TRIGEN PLANT SCREEN WELL
TRIGEN PLANT SCREEN WELL
WHERE ARE WE NOW?

FEMA New Approach - 2013

Nov.-Jan., 2015
City completes last remediation project. Certification report submitted to FEMA.

May, 2015
FEMA review letter.

April, 2016
Initiate process to respond to comments

June, 2016
Levee Analysis and Mapping Plan (LAMP)
The Project’s goal is to prepare a work plan on how FEMA should analyze and map the flood risk behind the St. Louis Flood Protection System using FEMA’s Levee Mapping and Analysis Procedures (LAMP) for non-accredited levees.

The Agency understands that the City of St. Louis is performing the required analysis and gathering documentation to gain accreditation for the St. Louis Flood Protection System. However, at this point in time FEMA must move forward to create a work plan to update the flood risk behind the levee, in keeping with its mission.
QUESTIONS?
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Stephen Randolph, P.E., CPESC, CFM, LEED Green Assoc.
St. Louis, Missouri

ASFPM National Conference, San Antonio, TX
May 24, 2012
Revised schedule due to high river levels

<table>
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<th>original due date</th>
<th>revised due date</th>
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<td>drilling complete</td>
<td>June 10, 2010</td>
<td>September 24, 2010</td>
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<td>100% of boring logs to City</td>
<td>July 24, 2010</td>
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<td>geotechnical lab testing</td>
<td>August 24, 2010</td>
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<td>draft report due to City</td>
<td>October 24, 2010</td>
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<tr>
<td>final report due to City</td>
<td>November 24, 2010</td>
<td>January 8, 2010</td>
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TRIGEN PLANT SCREEN WELL
Floodwall Inspections
Mound City Electric Plant
Riverview/Maline Creek Trench Drain

• Underseepage gradient exceeded current and original design criteria.
• Site of sand boils during 1993 flood.
• Uncooperative property owner.
• Intense review by USACE.
Riverview/Maline Creek Trench Drain
- Cooling water tunnel potential breach.
- Initial idea was to fill with grout.
- Owner preferred to keep tunnel open.
- Not enough freeboard in screen well.
- Access to site was difficult.
H&H RESULTS

NOTES:
1. TOP OF FLOOD PROTECTION LINE ON THE SHEET WAS PREPARED BY KEI (NAVD 1988).
3. CLOSURE STRUCTURE NOTATIONS (E.G. C-1) COMPLEMENT NAMING CONVENTION IN STRUCTURAL EVALUATION SECTIONS.
4. NOTATIONS SHOWN ABOVE THE PROFILE (E.G. F-1) ARE COE PROJECT REACH DESIGNATIONS.
Mound City Electric Plant
CREEK TRENCH DRAIN
INTERIOR DRAINAGE RESULTS

An analysis of the USACE Design Memorandums and the ASCE Journal article by the Chief of Hydraulics, showed that pump station capacity was provided to allow removal of storm runoff as quickly as it would arrive at the line of protection with storms coincidental with gate closing stage, or for storms coincident with the design flood, thereby with sufficient capacity to make flood storage volume unnecessary.
PROJECT CRITERIA

• FEMA vs. USACE
  FEMA 65-10 – Design Criteria “vague”
    Closures - “according to sound engineering practice”
    Embankment & Foundation Stability –
    “analyses that evaluate levee embankment stability must be submitted”
PROJECT CRITERIA

- FEMA vs. USACE
  - USACE – EC 1110-2-6067
  - Closures – EM 1110-2-2105
  - Embankment & Foundation Stability – EM 1110-2-1902
ABANDONED CONDUIT INVESTIGATION

Mound City Electric Plant
ABANDONED CONDUIT INVESTIGATION

• CSI St. Louis
  ➢ Monsanto Acid Sewer
  ➢ Anheuser-Busch Molasses Line
  ➢ Mound City Electric Plant
ABANDONED CONDUIT INVESTIGATION

Foot of Angelrodt Street
ABANDONED CONDUIT INVESTIGATION

Foot of Angelrodt Street
Horner & Shifrin, Inc.

Firm Overview

- Founded in 1933
- Offices in St. Louis, Springfield, and Poplar Bluff, MO, and O’Fallon, Chicago, and Rochester IL.
- 90 Employees, 42 Full-Time P.E.’s
- Full-Service Engineering Firm:
  - Mechanical
  - Electrical
  - Plumbing
  - Civil
  - Structural
  - GIS/Survey
  - Environmental
  - Transportation
  - Construction Administration
CONCLUSION
QUESTIONS?