The Inner Harbor Navigation Canal (IHNC) Surge Barrier Project - New Orleans

Winner
2011 ENR Infrastructure Project of the Year

Gerald R. Doton, P.E., Deputy Director of Engineering
Shaw Environmental & Infrastructure Group
March 23, 2011
Protecting New Orleans from Future Katrina Like Hurricanes
Southeast Louisiana Coast
Project Mission

- Provide flood risk reduction for a 1% annual chance storm event to the communities surrounding the IHNC by June 2011 (aka HYL A).
- Provide Advance Measures in order to reduce the risk of flooding in hurricane season 2009 & 2010.
- The IHNC is the “Linchpin” in the system – the Achilles Heel – the highest risk area. It is the 1st Construction Contract Award for the 100-yr level Risk Reduction System in the New Orleans area.
- The Largest Civil Works Design-Build Cost-Reimbursable Project in Corps’ History.
IHNC Proposal

• Opportunity was Identified Early.
• Over 1 Year Spent on Preparing Proposal
• Had to Develop Design Concepts and Solutions
• Design effort was to be 5% Level
  – Due to Innovative Design Concepts the Design Effort was Probably Closer to 10%. Had to Convince Corps Concept Would Work.
  – Advance Measures Considerations – Incorporation into Final Project Design
Corps Evaluation/Selection Criteria

Proposal was Evaluated for the Following:

- Most Probable Schedule
- Technical Solution
- Management Approach
- Estimated Cost & Most Probable Lifecycle Cost
- Socioeconomic Plan
IHNC Surge Barrier Project

• April 2008 – Shaw awarded project management, design, and construction contract from the U.S. Army Corps of Engineers (USACE)
• Largest design-build civil works project in USACE history
• 10,000-foot-long, 26-foot-high surge barrier & T-Wall
• Design Life = 100 years
• Flood gates (3)
  • A bypass barge gate and a sector gate on the Gulf Intracoastal Waterway (GIWW)
  • A vertical lift gate at Bayou Bienvenue and rock-reinforced T-style floodwalls
• Objectives
  – Achieve 100-year level storm protection by June 2011, the start of the 2011 hurricane season
  – Provide advanced measures in order to reduce the risk of flooding for the 2009 and 2010 hurricane seasons
IHNC Design Team

US Army Corps of Engineers

Environmental & Infrastructure Group

EUSTIS
Metairie, Louisiana
Lafayette, Louisiana
Gulfport, Mississippi

Gerwick

Linfeld, Hunter & Junius, Inc.
<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hurricane Katrina</td>
<td>Aug. 2005</td>
</tr>
<tr>
<td>RFP</td>
<td>Aug. 2007</td>
</tr>
<tr>
<td>5 percent Design Submission</td>
<td>Jan. 2008</td>
</tr>
<tr>
<td>Contract Award</td>
<td>Apr. 2008</td>
</tr>
<tr>
<td>Construction NTP</td>
<td>Dec. 2008</td>
</tr>
<tr>
<td>First 66-inch Pile Installed</td>
<td>May. 2009</td>
</tr>
<tr>
<td>100-Year-Level of Protection Achieved</td>
<td>Jun. 2011</td>
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</tbody>
</table>
Looking West

New Orleans

Lake Ponchartrain

MRGO

GIWW

Project Alignment
### Shaw Evaluated

**Seven Different Gate Options**

<table>
<thead>
<tr>
<th>Option</th>
<th>Alternative</th>
<th>Action / Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>G01</td>
<td>Sector Gate – “Dry” Construction</td>
<td>Selected as primary solution. Proven design, proven construction, and proven performance.</td>
</tr>
<tr>
<td>G02</td>
<td>Sector Gate – “Wet” Construction</td>
<td>Dropped – more costly than G01 and local construction contractors are not proficient with this method.</td>
</tr>
<tr>
<td>G03</td>
<td>Vertical Lift Gate</td>
<td>Selected as alternate solution. Demonstrated at Olmsted. Concerns with wind loads with gate in up position.</td>
</tr>
<tr>
<td>G04</td>
<td>Swing Gate – Steel</td>
<td>Dropped – does not meet operating timeframe or maintenance requirements. Concerns with opening under head.</td>
</tr>
<tr>
<td>G05</td>
<td>Swing Gate – Concrete</td>
<td>Dropped – does not meet operating timeframe. Concerns with opening under head.</td>
</tr>
<tr>
<td>G06</td>
<td>Roller Gate – Bussman</td>
<td>Dropped – does not meet operating timeframe. Concerns with opening under head.</td>
</tr>
<tr>
<td>G07</td>
<td>Voors Gate</td>
<td>Dropped – current designs are not believed to be resilient and would be difficult to construct.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Schedule Achievement</th>
<th>Cost</th>
<th>4 R’s Criteria</th>
<th>Environmental Impact</th>
<th>Team Confidence</th>
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</thead>
<tbody>
<tr>
<td>Advance Measures</td>
<td>O&amp;M</td>
<td>Resiliency</td>
<td>Constructability</td>
<td>Design Complexity</td>
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<tr>
<td>Total Construction</td>
<td>Life</td>
<td>Redundancy</td>
<td>Local Revision</td>
<td>Total Material</td>
</tr>
<tr>
<td>Incorporation into Assembly</td>
<td>G &amp; M</td>
<td>Reliability</td>
<td>Availability</td>
<td>Navigation Impact</td>
</tr>
</tbody>
</table>

- Selected solution: sector gate in the “dry” construction
- Alternate solution: vertical lift gate
- Also considered innovative roller and visor gates
Shaw Evaluated
12 Different **Barrier** Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Alternative</th>
<th>Action / Decision</th>
<th>Schedule Achievement</th>
<th>Cost</th>
<th>4 R’s Criteria</th>
<th>Expendability</th>
<th>Team Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>L09</td>
<td>Braced Concrete Pile Wall</td>
<td>Retain as primary solution. Provides robust system that can be constructed by local resources, Low O&amp;M.</td>
<td>G E E M L M L E G G G G L M G E E E L</td>
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<tr>
<td>L01</td>
<td>Large (e.g., 18” diameter) Caisson</td>
<td>Retain as alternate solution. Provides robust system with low O&amp;M.</td>
<td>U G E M L M L E E G E E M H G P P L</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>L02</td>
<td>Dumbell Caisson</td>
<td>Dropped – variant of L01. Can be re-evaluated if primary solution is not selected for further design.</td>
<td>U G E M L M L E E G E E M H G P P L</td>
<td></td>
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</tr>
<tr>
<td>L03</td>
<td>Open Cell Sheet Pile</td>
<td>Dropped - corrosion concerns with the sheet pile, high costs, and global stability concerns.</td>
<td>G G E M M M M G G P G G G L M G G E L</td>
<td></td>
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</tr>
<tr>
<td>L04</td>
<td>Earthen Levee</td>
<td>Dropped – high cost for acquiring and placing the clay and high O&amp;M cost for settlement. Also, resilience concerns from overtopping. Work will be significantly impacted by adverse weather.</td>
<td>P U E H H H H P P E G G H L G E P L</td>
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</tr>
<tr>
<td>L05</td>
<td>Pile-Supported Levee</td>
<td>Dropped – see L04. Savings from smaller levee footprint offset by higher cost for the piles.</td>
<td>P U E H H H H P P E G P P H L G E P L</td>
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<td></td>
</tr>
<tr>
<td>L06</td>
<td>Jet Grout Wall</td>
<td>Dropped – high cost for jet grouting/deep soil mixing and concrete wall. Also, significant amount of site construction potentially impacted by adverse weather.</td>
<td>P G E H L M L E G G G G L M G G E L</td>
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</tr>
<tr>
<td>L07</td>
<td>New T-Wall</td>
<td>Dropped – high cost for robust T-wall with piles, slow installation, and significant amount of site construction potentially impacted by adverse weather.</td>
<td>P G E H L M L E G G G G L M G E E E L</td>
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</tr>
<tr>
<td>L08</td>
<td>Brace Steel Sheet Pile Wall</td>
<td>Dropped - corrosion concerns with the sheet pile.</td>
<td>G E E M M M M G G P G G L M G E E E L</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>L10</td>
<td>Earth Levee with Soil Mixing</td>
<td>Dropped - see L04. Savings from smaller levee footprint offset by higher cost for the deep soil mixing.</td>
<td>P U E H M H M P G E G P H L G G P L</td>
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<tr>
<td>L11</td>
<td>Hybrid Box Levee with T-Wall</td>
<td>Dropped – difficult to attain Advance Measures; hybrid box cannot be cost-effectively built to an elevation to attain the Advance Measures so will still need T-wall. See L04 for soil placement and L07 for T-wall concerns</td>
<td>P G E M M M M G G G G G M M G G G L</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L12</td>
<td>Open Cell Sheet Pile with Earthen Levee</td>
<td>Dropped - see L03 and L04.</td>
<td>G G E M H M H P G G G G G M M G G G L</td>
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</tr>
</tbody>
</table>

- Selected solution: braced concrete pile wall
- Alternate solution: large diameter caissons
- Earthen levees discarded because of settlement, clay availability and resilience
- T-walls dropped because of high cost for T-walls, slow installation, and potential adverse weather impact
IHNC Surge Barrier Project
Project Overview

- BAYOU BIENVENUE LIFT GATE
- FLOODWALL
- GIWW BYPASS GATE
- NORTH & SOUTH T-WALL
- GIWW SECTOR GATE
Concept - Surge Barrier Flood Wall
Surge Barrier Flood Wall @ MRGO Closure
Installing Vertical & Closure Piles

Install & Drive Vertical & Closure Piles Using Alignment Template

66” dia. vertical concrete pile

Established Barrier Alignment

Alignment Template

Barge Mounted Crane (Work Barge)

Plan View A-A

Elev. 0 ft.

Elev. -15 ft.
Installing Batter Piles

Install & Drive 36" dia. batter Pile Using Steel Alignment Template
Installing Pre-Cast Horizontal Concrete Cap Beam

Concrete Inside Piles and Install Embedded Anchorages to Attach Pre-cast Horizontal Concrete Cap Beam Segments

Barge Mounted Crane (Work Barge)

Precast Horizontal Cap Beam

Elev. 0 ft.

Elev. -15 ft.
Placing Concrete Inside Pre-Cast Concrete Cap Beam  
– Advance Measures Complete

- Concrete Pump Truck
- Concrete Agitor Transport on Barge

Elev. 0 ft.
Elev. -15 ft.
Barrier Flood Wall
Final Protection
Start of Construction
Dredging and Test Pile Program
Access Channel Dredging

(Dredged 1.2 Million cy in 3 Weeks)
66” Spun Cast Piles (2 Suppliers)

- 1,272 Piles - 144’ Long
- 3,500 Segments Cast to Date
- 10,000 Segments Required
- 18”, 24”, 36” Concrete Piles
- 36” Steel Pipe Piles

66” diameter spun cast piles
Spun Cast Pile Assembly

- Post Tensioning Ducts
- Inject Grout (Concrete)
66” Pile Transport & Delivery

- Each pile weighed 96 tons
- Each 12-pile barge load weighed 1,152 tons or 2,304,000 lbs
First 66” Pile Being Driven
First Pile Driven to Elevation
500-ton Crane
Close Tolerances

- Driving Tolerances
  - Vertically 3"
  - Horizontally 6” Separation
Rail and Trestle System
“Assembly Line” Operations
(2,546) 18 inch square concrete closure piles were installed between each set of 66 inch piles.
18” Surge Barrier Closure Piles
Top 50’ of every 66 inch and 36 inch pile received rebar and concrete infill.
Concrete Delivery to Work Areas

- Trucks hold on average 10 yards of concrete
- 10 trucks per hour = 100 yards
- 250 trucks per day = 2,500 yards
36-inch Steel Batter Piles
Lifting 140’ long Batter Piles Sections (2 Sections = 250’)

Pile length limited by driving equipment
Lifting Batter Piles Into Template
Batter Pile Template Positioning
Batter Pile HDPE Jacket

- 2.75 inches thick
- Inject Grout

2.75 inches thick
Surge Barrier Precast Concrete Cap

345 Precast Caps
Weight = 60 tons each
(321) Cast-in-place road deck sections fill the gaps between precast sections.
Surge Barrier Parapet Wall

Closure Pours
Surge Barrier – Flood Side

- Completed flood side of wall.
- Storm surge protection for the city of New Orleans up to Elev +26
Surge Barrier – Protected Side

7,625 linear feet of Floodwall constructed. (1.44 miles)
ERDC Ship/Tow Simulators

- Reproduce vessel response to forces
- Real-Time
- 240 degree field of view
  - Can turn viewing angle 360 degrees
- Two simulators
  - Function independently or couple for two-way traffic
Empty 8-pack
(most difficult, max wind)

Wind gusting about 22 knots

Max Ebb

Preliminary
GIWW Sector & Barge Gates Open Positions

150'

Safe House
GIWW Floodgates **Closed** Position

- 75-foot diameter gate leaves
- Concrete Barge
- 150-foot opening
GIWW Bypass (Barge) Gate

• GIWW BYPASS GATE
Cofferdam @ GIWW Bypass Gate

- High density concrete mixture
- Self Leveling
- Tremie Mat - 5-ft
- Base Slab: 4-ft to 5-ft
5’ Tremie Concrete Placement @ Bypass
The base slab construction consisted of four mass concrete placements. All concrete trucks for the Bypass Gate and BB Gate were delivered via barge.
6,130 CY of concrete and 433 tons of rebar were used to build the Bypass abutment.
Cofferdam @ GIWW Sector Gate
Continuous 52 hour pour, 10,300 CY of concrete was placed.
8’ Structural Concrete Mat @ GIWW Sector Gate

The 8’ base slab construction comprised of 10 mass concrete pours.
Dewatered GIWW Gate Cofferdam
Radial Gate Leaves Fabricated Onshore
Delivery to Project Site
Transporting Swing Gates to Project Site

Sector Gates 84' Radius x 42' High
990 Tons each Leaf w/Roadway
Installing Swing Gates
The Sector Gates were floated into place.
Construction of Barge Gate
Completed Barge Gate

Barge 190’ long x 62.5’ deep x 42.4’ high
Weighs approx. 5,292 tons
Draft = 14’
Barge Gate Leaving Floating Drydock
Delivering Barge Gate to Project Site
Bayou Bienvenue Lift Gate Overview

- BAYOU BIENVENUE LIFT GATE
1100 CY of underwater tremie concrete was placed after construction of the 137.5 ft by 76 ft cofferdam.
4’ Tremie & 8’ Mat Placement @ at Bayou Bienvenue
BB GATE

The lift gate was constructed off site and delivered via barge. The gate is 60 ft long, 8 ft wide, and 34.5 ft high.
Lift Gate Delivered to Project Site

- Vertical Lift Gate = 109T
- 61’-4” wide x 8’-2” deep x 34’-6” high
Installation of Lift Gate
BB Lift Gate Structure
BB Gate w/ Tower & Bridge Structure
T-Wall Overview

The North and South T-Walls consumed 19,000 CY of concrete and 1700 tons of rebar.

The typical wall sections are 54 ft long, 5 ft thick, and 25 ft high.
T-Wall Mat Footings
North T-Wall Formwork
Project Nearing Completion
(Looking South)
IHNC Nearing Completion
(Looking North)
HYLA – Bypass & Swing Gate Closed

Hundred year storm protection for New Orleans obtained ahead of schedule.
GIWW Sector Gate
GIWW Bypass Gate (Barge Test Fit)

The Bypass Abutment and Barge Gate in the closed position.
BB Gate w/Tower & Bridge Structure
South T-Wall @ LPV-145
North End of the Surge Barrier & T-Wall @ LPV-111
Work Remaining

- Scheduled Completion & Turnover  06/01/2012
- Completion of Electrical & Mechanical Systems
- Walkdowns & Punchlist Items
- Startup, Testing, Training & Turnover
- O&M Manuals
- As-Built Drawings
Questions?